Chapter 5

Using Sediments to Rebuild and Restore Marsh and Shorelines

Prior to the extensive levee system and upstream navigation and flood control structures, overbank flooding from the Mississippi River delivered sediments to the marshes in coastal Louisiana. These sediments nourished the lands, offset the ongoing and natural deltaic process of subsidence, and countered the impacts of rise in sea level. Surface elevation must equal or exceed relative rise in sea level in order for coastal marshes to survive (Kemp et al. 1999). Unless wetlands accrete vertically, an increase in flooding duration stresses vegetation and it ultimately dies (Day et al. 2005). Marsh surface elevation in relationship to the tidal frame is a direct indicator of sustainability, and surfaces near the bottom of the tidal frame require direct placement of dredged material (Kemp et al. 1999).

Research has quantitatively shown that barrier island and wetland losses result in increased storm surge and wave energies impacting the Louisiana coast (Stone et al. 2003). Shoreline protection methods using rock breakwaters as the primary project feature have been a staple in Louisiana's coastal restoration efforts within the CWPPRA program (Hill 2005). Ease of construction, low cost, and material durability are primary reasons for its usage, however excessive settlement is a concern due to the clay soils in coastal Louisiana (Hill 2005). Strategically placing sediment on barrier islands, in canals, and other open water areas is one alternative to stone shoreline protection for coastal restoration. The availability, costs, and environmental impacts of the two diverse approaches to coastal restoration are examined.

5.1 Inland Restoration with Sediments

Marsh creation projects using dredged materials from nearby sources are not a new concept. The Bayou La Branche Wetland Creation CWPPRA project (PO-17) successfully placed 2.7 mcy of material dredged from Lake Pontchartrain into an adjacent open water area. This project created approximately 350 acres of shallow water habitat; 70% emergent marsh and 30% open water areas were achieved within five years of completion. The aerial photograph in Figure 5.1, taken approximately three years after construction, captures project results compared to an adjacent reference area.

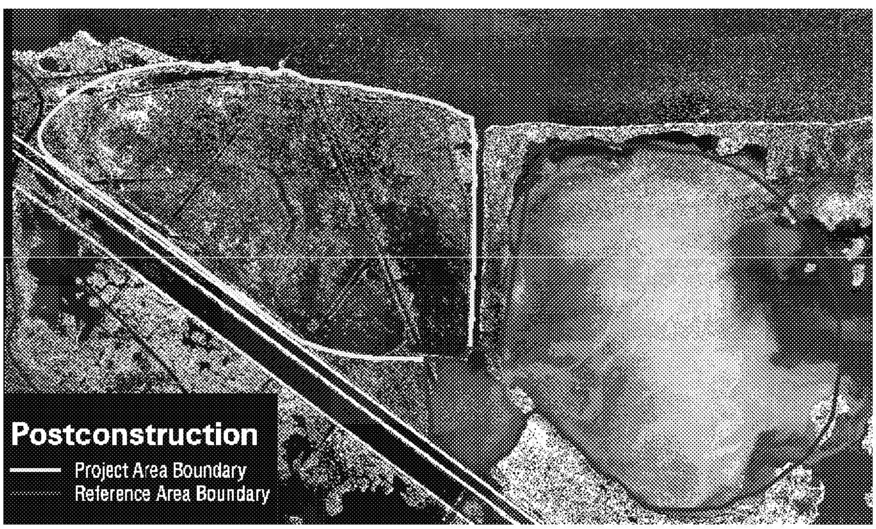

Figure 5.1 – Scaled aerial photograph of the Bayou La Branche Wetland Creation Project (PO-17) and reference in 1997 (Troutman 1998).

Immediately after project completion in 1994, concerns were expressed that the finished elevations of the sediment ranging from about 1.4 to 1.6 ft. NAVD 88 were too high to create the desired shallow-water habitat, as upland type vegetation colonized the area (McQuiddy 2005, Boshart PO-17 2003, Troutman 1998). However, continued monitoring and elevation surveys revealed that by 2002, eight years after construction, mean sediment elevation had settled from 1.6 ft. NAVD 88 to around 0.65 ft. NAVD 88 (Boshart PO-17 2003). The success of the Bayou La Branche CWPPRA project demonstrates the ability to restore inland open water areas into viable marsh habitat with the addition of sediment; however, the adjacent borrow site has not been monitored to determine the impacts of removing the material.

5.2 Barrier Island Nourishment

Barrier islands in coastal Louisiana not only provide wildlife habitat but also protect coastal wetlands by dampening wave action and reducing wave energy (Stone et al. 2003). Although engineering structures are still common, beach nourishment has become a standard alternative for dissipating wave energy and replenishing sediment supply (Kelley et al. 2004). Sophisticated finite element modeling has demonstrated that restoring the Isles Dernieres barrier islands in coastal Louisiana would provide marsh and shoreline protection (Stone et al. 2003). Surprisingly, barrier island type projects represent less than 9% (13/150) of CWPPRA authorized projects, and only 7% (6/82) of completed projects. One barrier island project, Raccoon Island Breakwater Demonstration project (TE-29), placed eight offshore-segmented breakwaters to protect the shoreline. There is ongoing discussion regarding the effectiveness of the Raccoon Island project. Some breakwaters trapped sand in their immediate vicinity but, in so doing, disrupted sediment transport to the west, creating an erosional shadow measuring 8,900 ft. in length as of May 2002 (DMJM 2005, Penland et al. 2003). The federal sponsor concedes some degree of accelerated erosion should be expected downstream of the structures, but believes the sediment accretion benefit behind the breakwaters outweighs down drift losses (NRCS 2005). Others contend that the positive benefits immediately landward of the structures are outweighed by the overall habitat loss on the island and accelerated shoreline retreat down drift (DMJM 2005, Penland et al. 2003). Raccoon Island, after the passage of Hurricanes Katrina and Rita in 2005, is shown in Figure 5.2. Breakwater #1 is not visible, off the right of the photograph.

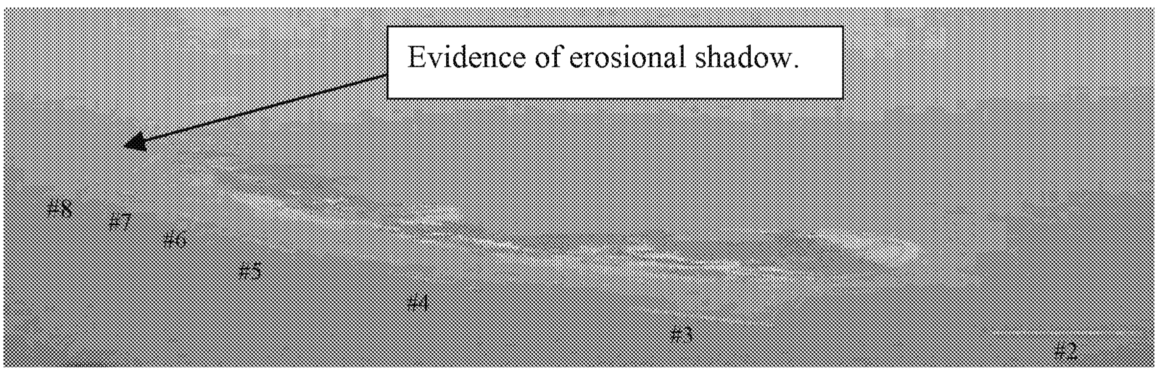

Figure 5.2 – October 13, 2005 photograph of Raccoon Island CWPPRA project TE-29 after Hurricanes Katrina and Rita.

In spite of the controversy, the CWPPRA Task Force authorized construction funds in 2005 for an additional protection project for Raccoon Island, placing eight more offshore-segmented breakwaters and a groin on the eastern end. Concerns over the expense and sustainability in using external sediments were cited as support for the breakwaters (NRCS 2005).

An alternative approach to protecting a barrier island protection was implemented by the Timbalier Island Dune and Marsh Restoration (TE-40) CWPPRA project. This barrier island/marsh creation project placed over four million cubic yards of dredged sediments to nourish and restore 2.2 miles of the island. An October 13, 2005 photograph of the Timbalier Island Dune and Marsh Restoration (TE-40) project is shown in Figure 5.3. The borrow source was located approximately 14,000 ft. offshore in the Gulf of Mexico. This project was bid in early 2004 and the awarded price per cubic yard of dredged material was $2.47. Dredging began in June 2004 and was completed in January 2005 with at least three de-mobilizations due to storm events. The stone shown in Figure 5.3 was placed on the backside of Timbalier Island by the Louisiana Department of Transportation and was not part of TE-40 (TBS 2002). When the stone was placed in the 1970s, approximately 1,500 ft. of land separated them and the Gulf of Mexico (Eells 2004). The stones are now fronting the Gulf of Mexico. In this dynamic environment, the island continues to migrate to the northwest leaving the stone behind. The down drift, erosional shadow caused by the stone is visible in Figure 5.3.

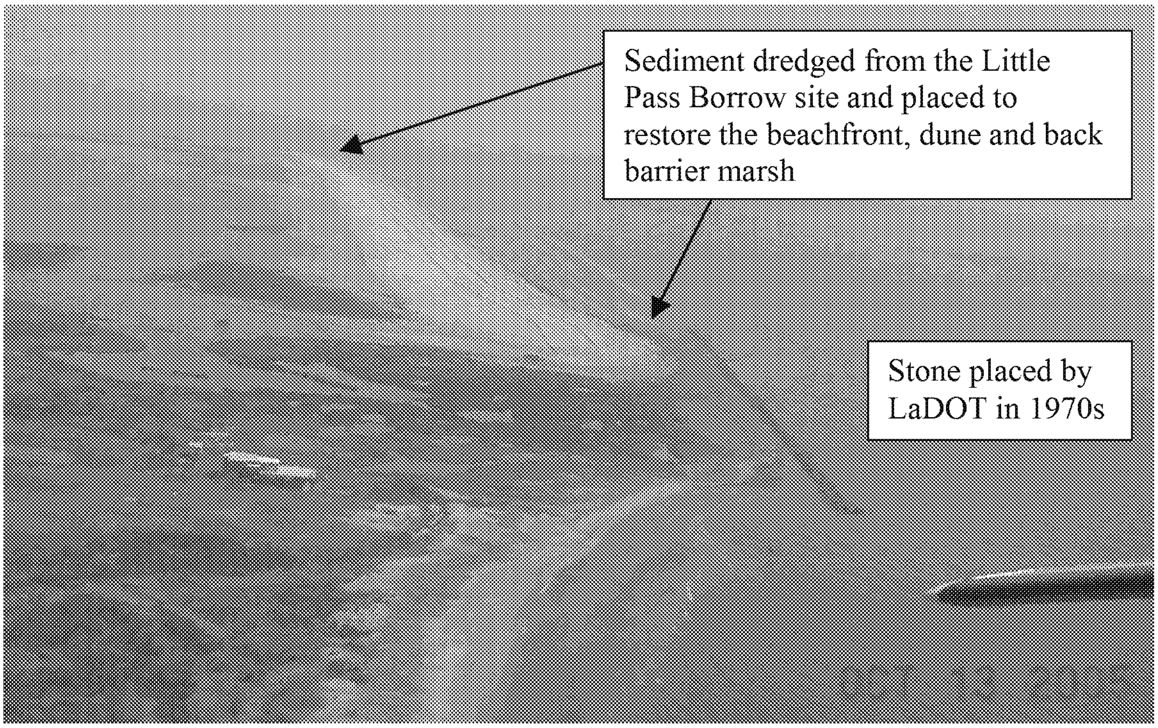

Figure 5.3 – October 13, 2005 photograph of Timbalier Island Dune and Marsh Restoration (TE-40) CWPPRA project after Hurricanes Katrina and Rita.

Georeferenced aerial photographs of the Timbalier project obtained by LDNR before and after construction, and after the passage of Hurricanes Katrina and Rita, are shown in Figure 5.4. The yellow dashed line approximately indicates the eastern project boundary. Water levels were still high in the bottom photograph, taken only five days after Hurricane Rita and a significant amount of sand was visible in the near shore areas (Williams 2006). Barrier islands often take six months to "heal" after significant storm events with material returning to shore from within the system (Williams 2006). The easternmost end of the island was not restored due to real estate issues, and is now open water. Clearly, the TE-40 project has extended the life of Timbalier Island and reflects the benefits of introducing sediment to restore the coastal Louisiana barrier islands.

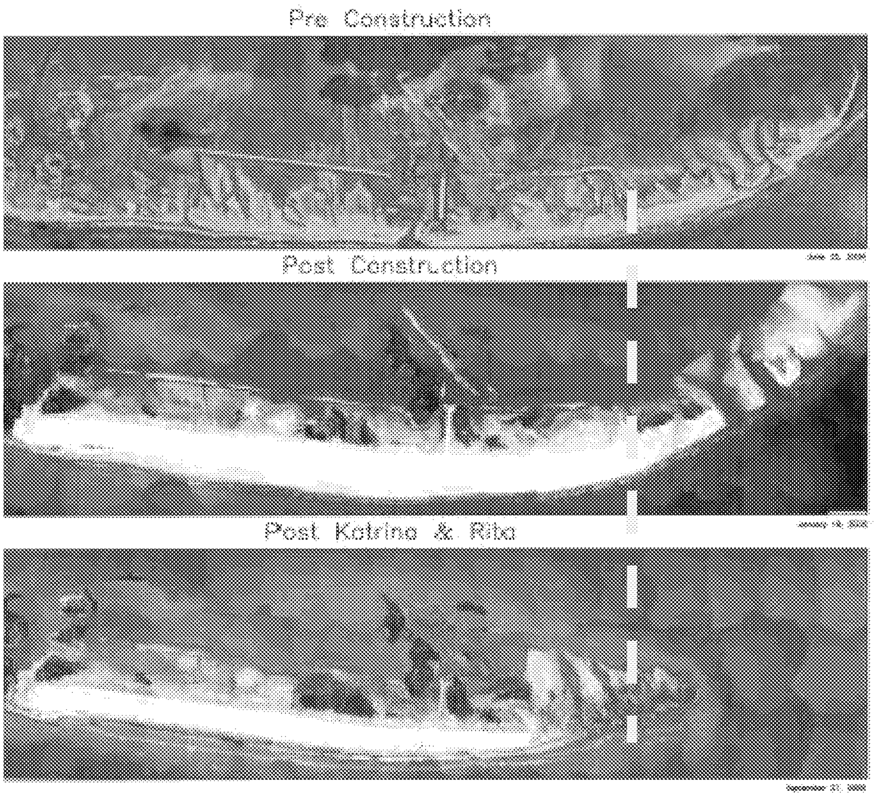

Figure 5.4 – Georeferenced aerial photograph of Timbalier Dune and Marsh Restoration (TE-40) Project pre and post-construction, and post hurricane.

5.3 Volume of Sediment Required

An estimate of the quantity of materials needed to address the 25 square mile annual land loss in coastal Louisiana is presented in Table 5.1. Depth of water calculations assume 75% of the open water area is shallow (equal to or less than 1.5 ft. deep) and 25% of the area is two ft. deep. The total volume estimated to reach mean water level is a little over 1 billion cubic ft. Volumes associated with fill heights ranging from two to four ft. above the water surface elevation are also calculated. The elevation of hydraulic fill impacts how fast material shrinks and settles and a 30 to 50% reduction in initial placement height is not unexpected (BCG 1998). Therefore, an initial fill height of four ft. above the mean water level is recommended to account for shrinkage, compaction, settlement, and subsidence. Using the most conservative estimate, it would take placement of approximately 100 mcy of material each year to offset 25 square miles of land loss by achieving a 70% land to 30% water ratio, like the Bayou La Branche project. Assuming two ft. of settlement and an additional foot of compaction of the newly placed materials, would result in a desirable intertidal marsh target elevation over time of approximately one ft. In comparison, the West Lake Boudreau Shoreline Protection and Marsh Creation (TE-46) Project team consisting of LDNR, USFWS, and NRCS determined a +1.3 ft. NAVD 88 was a desirable marsh elevation for that area (Hill and Brass 2005). Actual settlement and long term consolidation values would vary depending upon the physical characteristics of the fill material, depth of water, sea level rise, and soil foundation conditions at each placement site.

Table 5.1 – Volume of materials needed to address one year of land loss in Louisiana.

Annual land loss		25	sq miles		
		16,000	acres		
		696,960,000	sq feet		
					Total volume
depth of water (feet)		**1.0**	**1.5**	**2.0**	**under water**
% of area		0.25	0.5	0.25	**(cu ft)**
volume under water (cu ft)		174,240,000	522,720,000	348,480,000	1,045,440,000
					70/30 land/water
		Total Fill Volume	**Total Fill Volume**	**Total Fill Volume**	**Total Fill Volume**
		above water	**Required (cu ft)**	**Required (cu yd)**	**Required (cu yd)**
fill height	2	1,393,920,000	2,439,360,000	90,346,667	63,242,667
above	3	2,090,880,000	3,136,320,000	116,160,000	81,312,000
water level (feet)	4	2,787,840,000	3,833,280,000	141,973,333	99,381,333

5.4 Sources of Material

Rebuilding the interior marshes and barrier islands requires sediment and/or coarse sand. Ideally, restoring wetlands involves placing relatively fine sediments, while barrier island restoration utilizes coarse sands on the beach front and finer grained materials are highly desirable on the back marsh. Current restoration projects often use adjacent materials; however, in a sediment deprived environment, this practice results in no net gain of material. Long-term impacts and effects of dredging the adjacent materials have not been determined.

Three sources of material that could be used to directly address coastal Louisiana land loss were examined:

1) Mississippi River sediments in and around coastal Louisiana;
2) Mississippi River System sediments upstream of coastal Louisiana, including portions of the Upper Mississippi (Illinois Waterway) and the Arkansas River system; and,
3) sandy sediments in the Black Warrior – Tombigbee River system.

5.5 Mississippi River Sediments In and Around Coastal Louisiana

Sediments in and around coastal Louisiana are defined herein as materials dredged by USACE, New Orleans District, and Mississippi River deposits downstream of Baton Rouge. The USACE, New Orleans District, is responsible for maintaining all navigable waterways within its District boundaries and has the largest annual channel operations and maintenance program in the USACE (USACE 2004). This volume is approximately

36% of the total quantity dredged by USACE Districts for 2004, as represented in Figure 5.5.

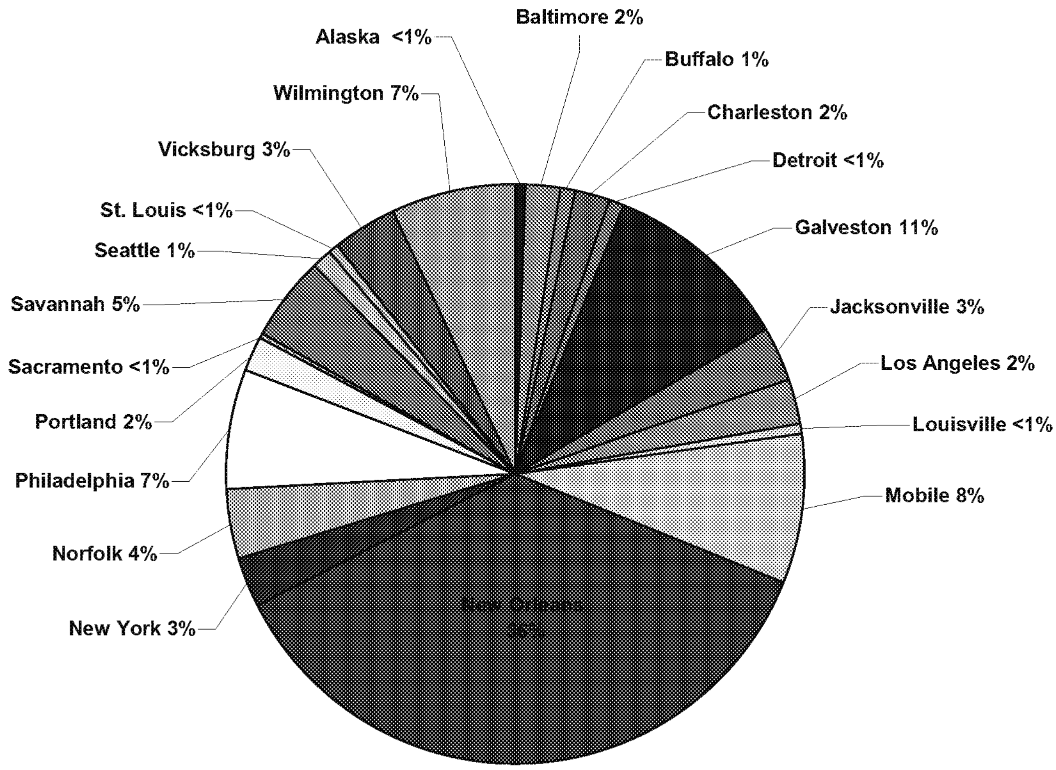

Figure 5.5 USACE District dredging percentages for 2004 (IWR 2004).

Physical characteristics of dredged material such as the percentage of sand, silt, and clay are usually known. New Orleans District dredges an average of 70 mcy of material annually yet only 14.5 mcy of dredged material was used beneficially in 2004 (USACE 2004). The volume available for reuse varies each year depending upon the type of dredging and environmental setting (USACE 2004). For example, the District's maintenance dredging plan for fiscal year 2006 included dredging and disposing of more than 109 mcy of material (USACE FY 2006). Dredged material was to be placed in upland sites, back into the channels, or in ocean dredged material sites in the Gulf of Mexico (USACE FY 2006). At most, only 50% of the 2006 dredged material volume was planned for reuse. Additional volumes of material resulted from emergency dredging due to Hurricanes Katrina and Rita, which made landfall in Louisiana on August 29, 2005 and September 26, 2005, respectfully. The focus of emergency dredging is clearing and reopening navigable waterways as quickly as possible, nearly eliminating opportunities for beneficial use.

Based upon the conservative estimate in Table 5.1, New Orleans District average annual dredged volume could address nearly 70% of the annual land loss. The USACE presents a more conservative estimate and states that placing 60 mcy of dredged material in water bodies up to 3 ft. deep and including compaction, subsidence and consolidation effects could result in creating only 4,300 acres, or approximately 28% of the annual land loss (USACE 2004). Unfortunately, not all of the dredged material is available for reuse, some is resuspended as a result of upstream maintenance (USACE 2004). Beneficial use of dredged material often requires additional handling and/or transportation of materials, increasing costs. Restrictions on the use of federal dollars present another obstacle to beneficial use. The USACE is required to determine and utilize the "least costly method of transport and disposal consistent with sound engineering practice and meeting all Federal environmental regulations" (federal standard), or secure additional special funding to pay the extra costs (USACE 2004). Supplemental funding sources include Section 204 or Section 1135 projects or special appropriations from WRDA. USACE estimates beneficial use of dredged material to cost an additional $1.00 per cubic yard based upon previous Section 204 projects (USACE 2004). This is a considerable cost savings compared to typical CWPPRA marsh creation material costs that can range from $2.75 to $4.00 per cubic yard. The LCA Study also recommends funding authority to implement more beneficial use of dredged material. At least one CWPPRA project, Sabine Refuge Marsh Creation Project (CS-28) has created placement areas for material dredged from the Calcasieu River and Pass. CWPPRA project funds paid costs beyond the federal standard in order to place material on the refuge. If supplementary funding were available, the USACE estimates an additional 30 mcy of material annually could be beneficially used (USACE 2004).

Even if monetary obstructions are overcome, real estate issues and oyster leases can still impede sediment placement in coastal Louisiana. For example, areas available for beneficial use of dredged material along the 37 mile Barataria Bay Waterway are limited because of oyster leases adjacent to the waterway (UNO 2001). Oysters are sensitive to turbidity; therefore, dredged material must be confined or semi-confined in order to prevent adverse impacts to the oyster leases (UNO 2001). As a result, beneficial use of material dredged to maintain the Barataria Bay Waterway has only taken place below mile 16 to mile -3.8. Open water areas that could benefit from placement of this material were shown previously in Chapter 3. Employing screens or curtains can minimize turbidity associated with dredging or placing materials. The State of Louisiana legislature recently passed legislation which may alleviate the oyster lease compensation issues potentially interfering with restoration.

The USACE usually contracts their dredging. Dredging operations are seasonal, for example, rough seas in the Gulf of Mexico during the winter months (November to March/April) are not conducive to operating a cutterhead dredge working with a long pipeline (Creef 2005). Some dredging is performed by hopper dredges, very large vessels, which require significant water depths. Unfortunately, the time required to manage activities, modify contract specifications, and coordinate the timing of contract awards are further impediments to beneficial use. Developing a process to stockpile dredged material for future use by CWPPRA projects should be implemented to maximize beneficial use. Multiple stockpile locations could be land based or confined aquatic facilities. Designated confined aquatic facilities offshore would also enable accumulation of hopper dredged materials for future placement. Once stockpiled, materials could be used as needed, transported to CWPPRA projects by barge and/or via pipeline. Stockpiling would require additional handling and results in higher costs. Coordinating a prioritized list of CWPPRA projects, identifying potential locations and volumes, would facilitate direct placement and utilization of dredged material. Assuming resolution of all issues, relying upon 100% usage of the New Orleans District yearly dredged material is not enough to offset annual land loss, therefore additional sources of material are needed to simply maintain the land to water ratio "status quo" in coastal Louisiana.

5.5.1. Local Resources in the Mississippi River

There are various types of sediments in the Mississippi River, and some of these may be considered suitable additional sources of sediment for rebuilding interior marsh and/or barrier island restoration. Attempts to utilize the "muddy" Mississippi are underway. The Mississippi River Sediment Trap CWPPRA project, MR-12, currently in the engineering and design phase, is intended to trap sediment by constructing a large pit along the bottom of the river. Sediment traps have also been discussed in the LCA study. USACE estimates the annual yield for a sediment trap above the Head of Passes area to be approximately 9 mcy (USACE 2004). This volume would address nearly 10% of the annual land loss according to the estimate in Table 5.1. Traps could be considered renewable sources of sediment since USACE experiences at RM 64, i.e. 64 miles above Head of Passes, indicate that borrow pits are usually filled within one year (CPE 2004). A borrow pit within the river should be monitored to determine timing, quantity and quality of the infill (CPE 2004).

An investigation conducted by Coastal Planning & Engineering, Inc. for the Riverine Sand Mining/Scofield Island Restoration (BA-40) CWPPRA project identified and assessed three potential sand sources within the Mississippi River:

- sand sheets, (bed load or sand waves);
- relict and deltaic sand below the fluvial sand sheets; and,
- relict point bars (CPE 2004).

CPE estimates the availability of sand deposits 20 and 35 miles upriver from Head of Passes, ranges from 6.15 to 20.5 mcy of materials appropriate for barrier island restoration (CPE 2004).

The impacts and sustainability of mining river sediments must be considered. Sediment transport is a dynamic phenomenon and measuring bedload is extremely difficult (Ongley 2005). Due to the length of time it takes for CWPPRA projects, especially barrier island restoration projects, to proceed from engineering and design to construction, constantly changing river conditions may impact the location and availability of sediment sources. Removing large deposits from the river could affect channel stability and indirectly impact navigation.

The sediment load of the Mississippi River has declined significantly in the past 50 years (USGS BRD 2005). Suspended sediments in the Mississippi River have been reduced as a result of the upstream dams constructed in the upper Mississippi River (Day et al. 2005). Average sediment load in 1951 was 1,576,000 tons per day, compared to 219,000 tons per day in 1988 (NPS MS 2005). This reduction is apparently occurring within the entire Mississippi River drainage basin. Sediment transported and deposited in the MKARNS is continually decreasing (USACE SWL 2005). Dr. Mead Allison, Tulane University geologist, believes sediments carried by the Mississippi River are a finite quantity and eventually there will not be enough sediment to meet all of the project needs (Water Marks 2005). EPA and the USACE are initiating an effort to develop a sediment inventory of the river. It is apparent that sediment sources outside of the Mississippi River local resources are needed to address ongoing and historical land loss.

5.6 Mississippi River System

Prior to upstream engineered structures, sediments were naturally transported by the river into the wetlands and continually built the coastal Louisiana lands, offsetting subsidence and rise in sea level. Existing upstream navigation and flood control structures must be circumvented to allow material to once again travel to coastal Louisiana.

5.6.1 Bypassing the Control Structures – Flushing the River

On November 22, 2004, the Bureau of Reclamation released water at a rate of 41,000 cubic ft. per second for 90 hours from the lower gates of Glen Canyon Dam near Page, Arizona, to distribute 800,000 metric tons of sediment and maintain ecosystems downstream on the Colorado River (Bauman 2004). An eighteen-month study is underway to determine the results of the release (Bauman 2004). Unlike the Mississippi River, the Colorado River is not an inland navigable waterway. It would be economically and physically counterproductive to stage a sequenced flushing of the upstream Mississippi River reservoir projects currently trapping sediment. The USACE maintains the inland waterway system and introducing more sediment would require additional maintenance dredging. River traffic may have to be delayed during the high flows and turbulence associated with "flushing", and halting navigation would be economically unacceptable. During the 1993 flood on the Upper Mississippi, traffic decreased 30 to 35% and losses to shippers were estimated at $700,000 per day (Petersen 1997).

High flows and currents may adversely impact the structural stability of flood control levees further increasing levee maintenance costs. There are numerous water supply intakes along the river and the increased turbidity would impact the quality of drinking water for numerous communities and increase treatment operations and costs. Ecological impacts to benthic organisms and other aquatic species due to increased sediments and turbidity could be severe. Travel times of the sediments from their release point upstream to coastal Louisiana is uncertain, it is possible the sediments would not be available in Louisiana for several years. Without a manner to effectively capture the coarse-grained sediments, and/or river reintroductions of Mississippi River water into the adjoining wetlands to distribute suspended sediments, material would be funneled into the Gulf of Mexico and lost beyond the continental shelf. Consequently, the deposition, quality, and quantity of materials that would be available for land building from a flushing are uncertain.

Instead of flushing through the system, sediment could be placed on barges and transported to coastal Louisiana using the inland waterway system. Significant quantities of sediment are currently available in the Illinois River system and additional materials are available in the Arkansas River system. The potential for using these materials to rebuild coastal Louisiana lands is worthy of investigation.

5.6.2 Illinois Waterway Dredged Materials

The Illinois Waterway is 327 miles long and supports a 9-ft. navigation channel connecting the Mississippi River with Lake Michigan (Marlin 2002). Channels, levees, and dams have impacted the hydrology of the floodplain and backwaters resulting in sediment deposition (Marlin 2002). According to the Illinois State Water Survey, 13.8 million tons of sediment are delivered to the river valley each year; 5.6 million tons are carried to the Mississippi River; and the remaining 8.2 million tons are deposited into the valley which includes the backwater and side channel lakes (Marlin 2002). Over time, this sediment has filled in the lakes, changing the ecosystem. Efforts are currently underway to restore the Illinois River ecosystem by removing the accumulated sediment resulting from erosion of Illinois farmland, streambanks and streambeds. A map of the Illinois Waterway is shown in Figure 5.6.

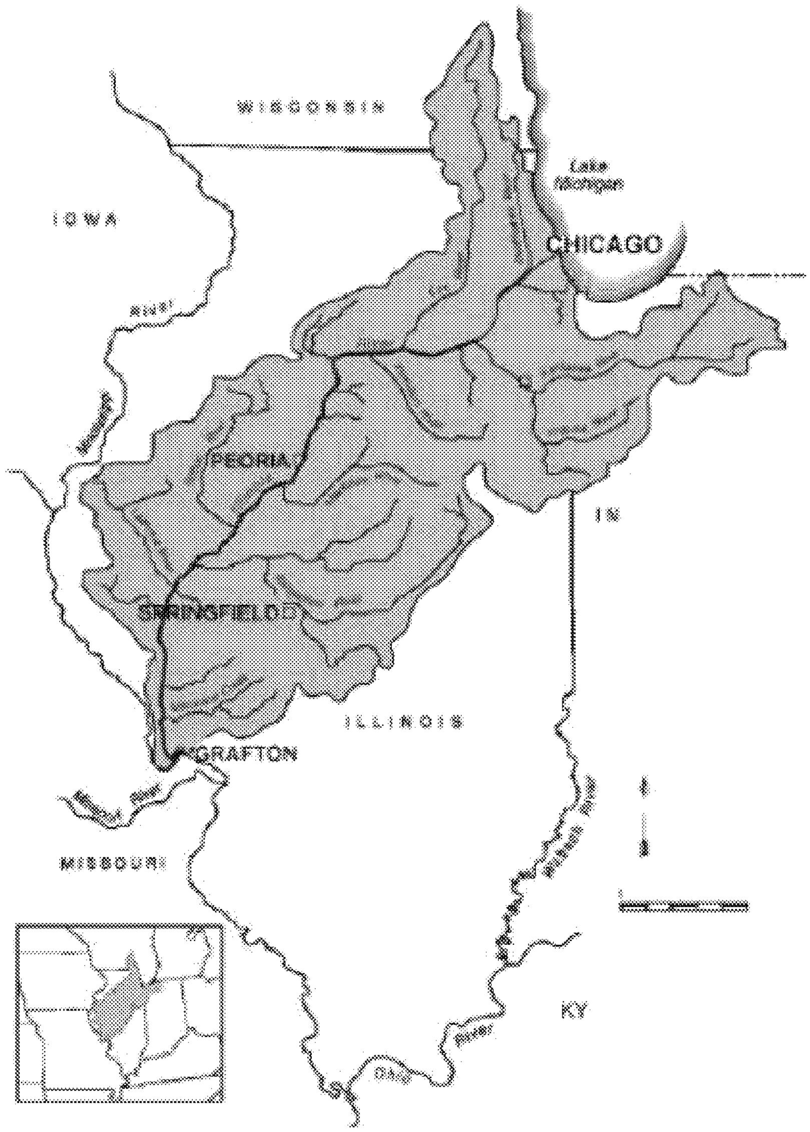

Figure 5.6 – Map of Illinois River drainage basin.

At least 150 million tons (117,831,893 cubic yards) of sediment are available within the Illinois Waterway system (Marlin 2005). This material could address more than one year of land loss, restoring over 29 square miles, based upon the 70% land to 30% water ratio and placement depth calculations presented in Table 5.1. Barging the material is one way to bypass upstream structures and levees currently preventing this material from rebuilding the Mississippi delta.

5.6.3 Arkansas River Navigation System Dredged Materials

Another source of materials within the Mississippi River system is from the Arkansas River navigation system. The fourth longest in the United States, the Arkansas River is also the sixteenth longest in the world (USACE SWL 2005). Six major tributaries flow into the Arkansas River, including the Cimarron, Canadian, Neosho, Grand, Verdigris, and White rivers (USACE SWL 2005). The MKARNS begins on the Verdigris River at the Port of Catoosa, and flows through Oklahoma and Arkansas to its confluence with the Mississippi River (USACE SWL 2005). A map of the MKARNS is shown in Figure 5.7.

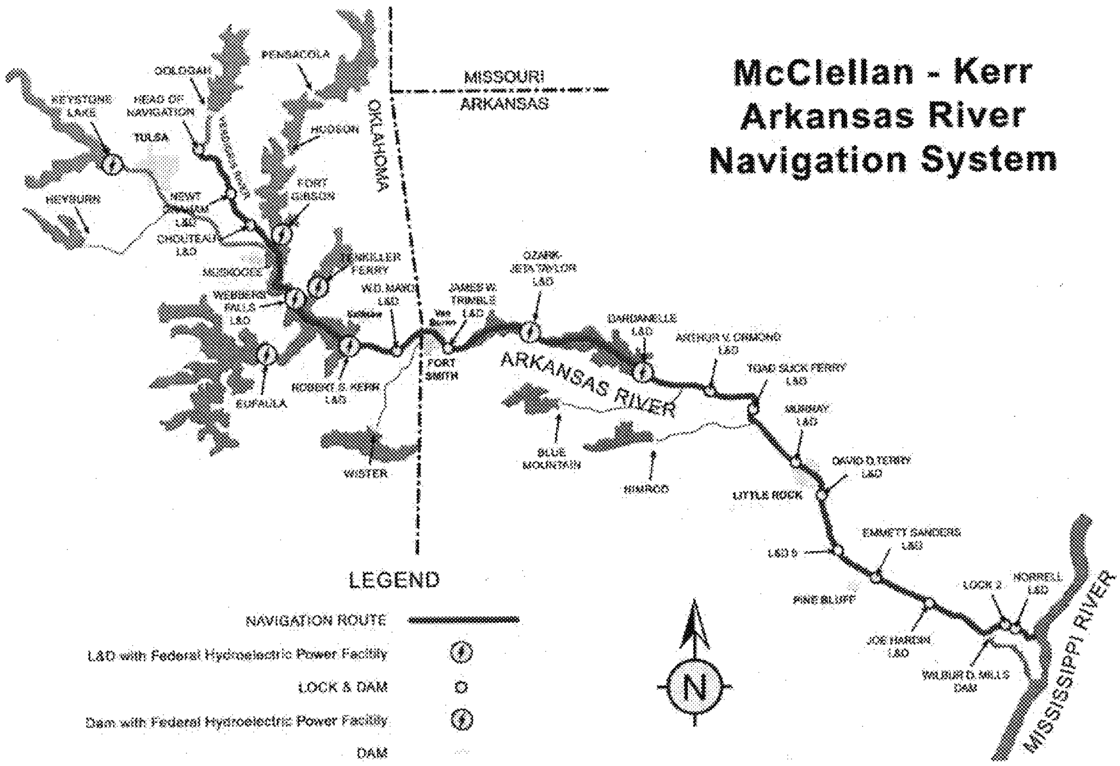

Figure 5.7 – Map of MKARNS.

A USACE study is underway to evaluate deepening the navigation channel from 9 ft. to 12 ft. A total of 10,985,340 cubic yards of material is anticipated to be dredged in order to deepen the MKARNS channel to 12 ft. over a three-year time frame (USACE SWL 2005). Nearly 11% of the annual land loss would be addressed by placing this material in accordance with Table 5.1. The anticipated distribution of the dredged materials along the length of the Arkansas River is shown in Figure 5.8. Notice that approximately 60% of the material will be dredged upstream of RM 250.

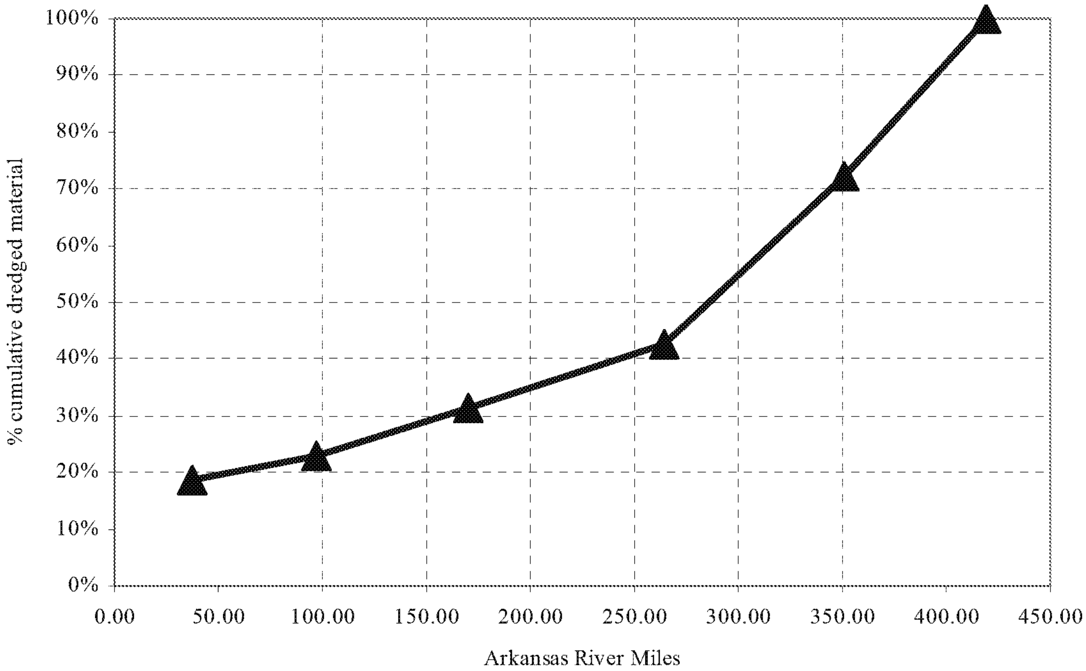

Figure 5.8 – Dredged volumes in the MKARNS.

In addition to the deepening project, the USACE, Tulsa and Little Rock Districts, maintain the MKARNS navigation depth by maintenance dredging. Approximately 300,000 cubic yards of material is dredged annually to maintain navigation (USACE SWL 2005). From 1971 to 2002 an estimated total of 50.4 mcy of material was dredged (USACE SWL 2005). The Oklahoma Department of Environmental Quality did not approve in-stream disposal, so dredged materials in the Oklahoma reach were placed in terrestrial sites (USACE SWL 2005). Over the next 20 years, maintaining the MKARNS to the existing 9 ft. channel depth will require dredging an estimated 7 mcy of sediment (USACE SWL 2005). The historical dredged volumes per year are presented in Table 5.2

Table 5.2 – Average dredged volume for MKARNS (USACE SWL 2005).

Year	Volume (mcy)
1971 - 1978	3.5
1979 - 1986	1.3
1987 - 1994	1.2
1995 - 2002	0.3

Note the yearly volume declined over 91% from 1978 to 1995. This continued reduction in dredging is attributed to the river system adjusting to the river training structures and bank stabilization measures (USACE SWL 2005). The new 12 ft. deep channel is estimated to impact maintenance dredging by an additional 820,000 cubic yards over that required for the existing channel (USACE SWL 2005). Thus, approximately 1.12 mcy of material would be dredged annually and could be available for beneficial use. Based upon the estimate in Table 5.1, this material would address approximately 1% of the annual land loss in Louisiana.

5.7 Sandy Sediments in Nearby River Systems – Black Warrior - Tombigbee River System, Alabama

Sand rich sediment is uncommon in the Louisiana fine-grained stratigraphy (Kulp et al. 2005). For example, sand is a limited resource along the Timbalier Islands (USACE LCA 2002). Without sufficient natural sand supply into the coastal environment, barrier islands must be artificially nourished periodically (Day et al. 2005).

The only viable, large-scale source of compatible sand for Louisiana barrier islands appears to be an offshore topographic feature called Ship Shoal, about nine miles away from the barrier islands at its closest point (MMS 2005). With a length of 31 miles, Ship Shoal could be a major source of sandy sediments for barrier island restoration. However, the presence of many pipelines, flowlines, and other pieces of oil infrastructure may limit dredging in certain areas (Kulp et al. 2003), and MMS considers offshore sand to be a non-renewable resource (Michel 2004). Some CWPPRA projects in the engineering and design phase have already specified Ship Shoal as their borrow source, but MMS expects demand and costs to increase for outercontinental shelf sand sources as nearshore sources are further depleted (Michel 2004). For example, NMFS has identified four projects for restoring over ten miles of the Barataria Bay barrier islands, and they estimate that approximately eight to ten mcy of sand will be required (LSMWG 2004). Future restoration projects having a total length of 15 to 20 miles may require an additional 30 mcy of sand (LSMWG 2004). The Coastal Studies Institute at Louisiana State University is currently investigating the impacts of mining Ship Shoal sand resources for large-scale beach and coastal restoration in Louisiana. Modeling studies indicate that the Ship Shoal area has a significant beneficial influence on regional hydrodynamics, reducing wave energy and modulating current velocity (Stone et al. 2005). Wave heights may be increased if excessive amounts of sediment are extracted from nearshore locations (Kulp et al. 2005), increasing the intensity of shoreline erosion forces, and negatively impacting the very barrier island restoration projects where the extracted sand was placed.

A sustainable alternative to consuming offshore sediment resources is using sand dredged by the USACE, Mobile District, to maintain the Black Warrior - Tombigbee

(BWT) River system. The banks of the BWT River system are unstable and eroding due to natural riverine processes and boat traffic. Eroding sands are deposited into the navigation channel, which must be dredged to maintain the minimum standard inland waterway depth of nine ft. A hydrographic survey boat, the EB Wallace, continuously conducts hydrographic channel condition surveys to determine the need for dredging and to verify dredged quantities. The survey boat on the BWT River system is shown in Figure 5.9.

Figure 5.9 – EB Wallace hydrographic survey boat profiling the BWT River system.

The USACE, Mobile District, maintains 27 upland storage locations along the BWT River system for the dredged material. These sites range in size from 22 to 70 acres, and currently contain nearly 30 mcy of dredged materials in dry storage. The locations of these sites, and a listing of their names and locations are shown in Figure 5.10.

DISPOSAL SITES and LOCK & DAM LOCATIONS 2004		
Disposal Site/Lock & Dam	Name	River Mile
L&D	Bankhead L&D	365.0
L&D	Holt L&D	347.0
L&D	Oliver L&D	338.0
BD	Ophelia	329.0
BE	North Star Wreck	324.0
BG	21 Mile Bar	318.0
AG	Little Log Shoals	313.0
AF	Bald Bar/Big Sandy	307.0
AE	Toxey Bend	300.0
AD	Burroughs	299.0
BA	Gray's Bluff	298.0
BF	Jones Field	280.0
L&D	Selden Dam	262.0
BC	Selden Lock	262.0
L&D	Selden Lock	261.0

AREA 1 - runs from Selden Lock and Dam at River Mile 261, up to River Mile 329.

L&D	Demopolis L&D	213.0
Ca-1	Old Lock 3	191.0
L&D	Coffeeville L&D	116.6
AC	Coffeeville	116.5
Z	Buena Vista	109.0
X	Buena Vista	108.5
X-3	Buena Vista	108.5
X-4	Buena Vista	108.3
X-2	Buena Vista	108.0
R	Little McGrews	105.0
O	Ballfield	104.0
N	Peavey's	103.5
J	St. Elmo's	95.0
I	Lower Princes	92.0
F	Blackwells	89.0
E-2	East Bassetts	87.0
E	Singleton	85.0
D-1	George Gaines	82.5
C	Sunflower	78.5
A	Newman Bend	73.5

AREA 2 - there is one disposal site at River Mile 190 and the rest fall below Coffeeville at River Mile 116, down to River Mile 73.

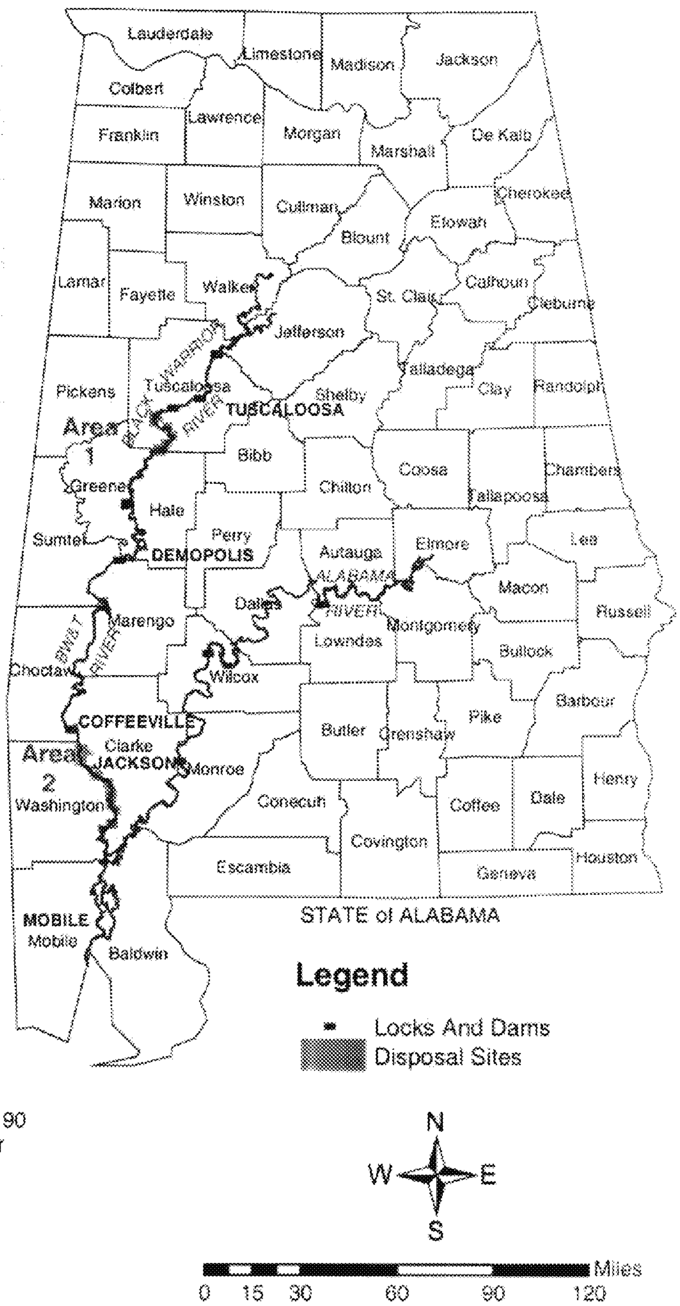

Figure 5.10 – Names and locations of 27 upland BWT storage sites courtesy of USACE, Mobile District.

Some sites are located on private property through perpetual easements, and others are on government lands. In addition to placement on adjoining lands, dredged material is also placed along the banks of the river. This material eventually re-enters the channel due to natural erosion and must be re-dredged. The close proximity of a storage site, demonstrating the potential for dredged material to re-enter the river, is shown in Figure 5.11

Figure 5.11 – Upland site Buena Vista Z, along the BWT Waterway, Alabama

The 40-acre Buena Vista Site Z, shown in Figures 5.11 and 5.12, is located on the right bank at RM 108.6. Mr. Fred Horn of USACE, Mobile District, Black Warrior-

Tombigbee/Coosa-Alabama Project Management Office, is highlighted in Figure 5.12 for purposes of scale.

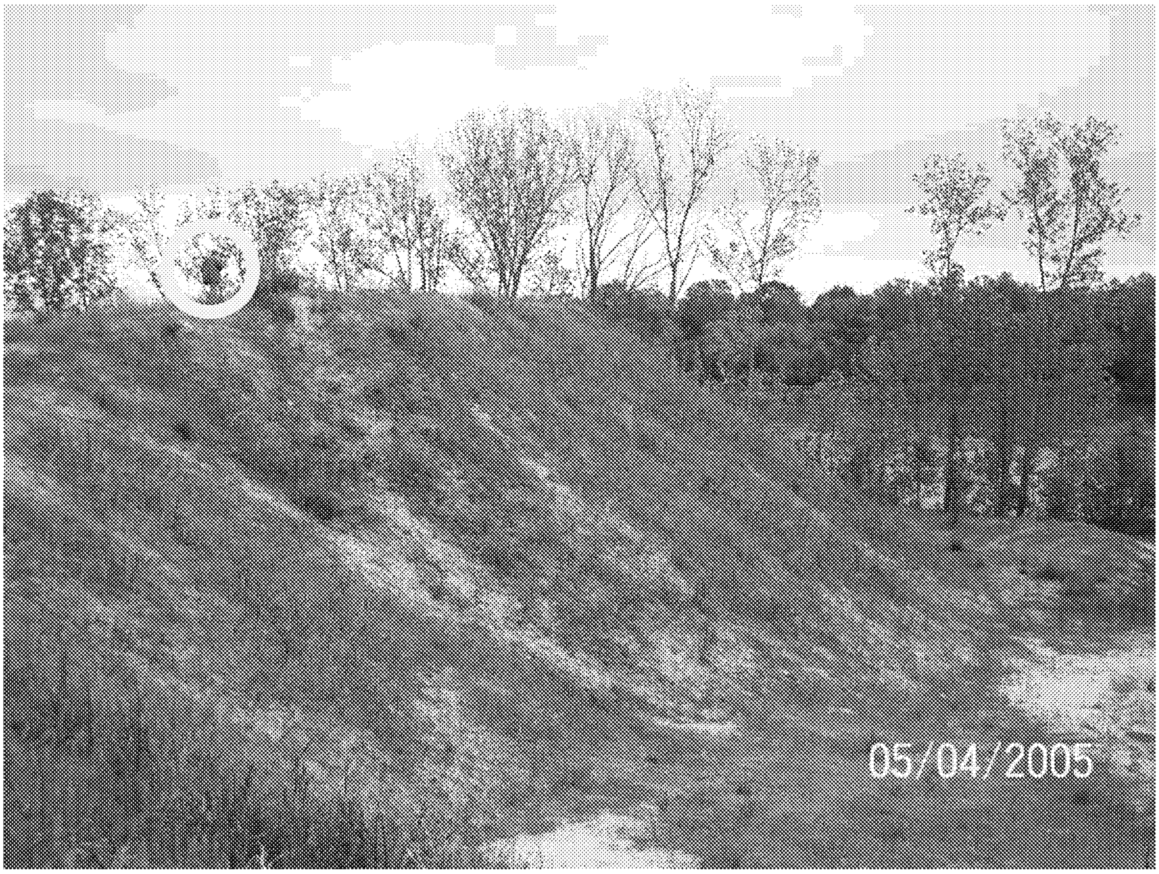

Figure 5.12 – Buena Vista Site Z, RM 108.6, BWT Waterway, Alabama.

This sandy material is in dry storage, readily accessible and adjacent to the river with 9 ft. deep navigable access. Barges can tie up to the riverbanks at the storage sites and conveyors can be used to load the sandy material onto barges for transport to coastal Louisiana. The interior of the 40-acre Buena Vista Z storage site containing approximately 1.25 mcy of material is shown in Figure 5.13. Mr. Horn is again highlighted in Figure 5.13 for purposes of scale. The elevation of this material is approximately 90 ft. higher than the water level in the waterway (Horn 2005).

Figure 5.13 – Interior of Buena Vista Site Z, RM 108.6, BWT Waterway, Alabama.

The most upstream of the storage locations is the Ophelia site (RM 329) located just downstream of Tuscaloosa, Alabama, and about 486 river miles from New Orleans. Another BWT storage location is the Sunflower site, located at RM 78, about 400 ft. from the edge of the river (SAM 2005). Approximately 1.8 mcy of dredged material covers a

70-acre area, 35 ft. high, in the place of former bottomland hardwoods (Horn 2005, SAM 2005). This storage site is near capacity, with its height already exceeding the 20-ft. high earthen containment dike by over 15 ft. in most locations. The site closest to New Orleans is located at RM 73.5. The percentage distribution of the material stored along the waterway is shown in Figure 5.14. Approximately 50% of the stored material is located within 108 river miles upstream of Mobile, Alabama.

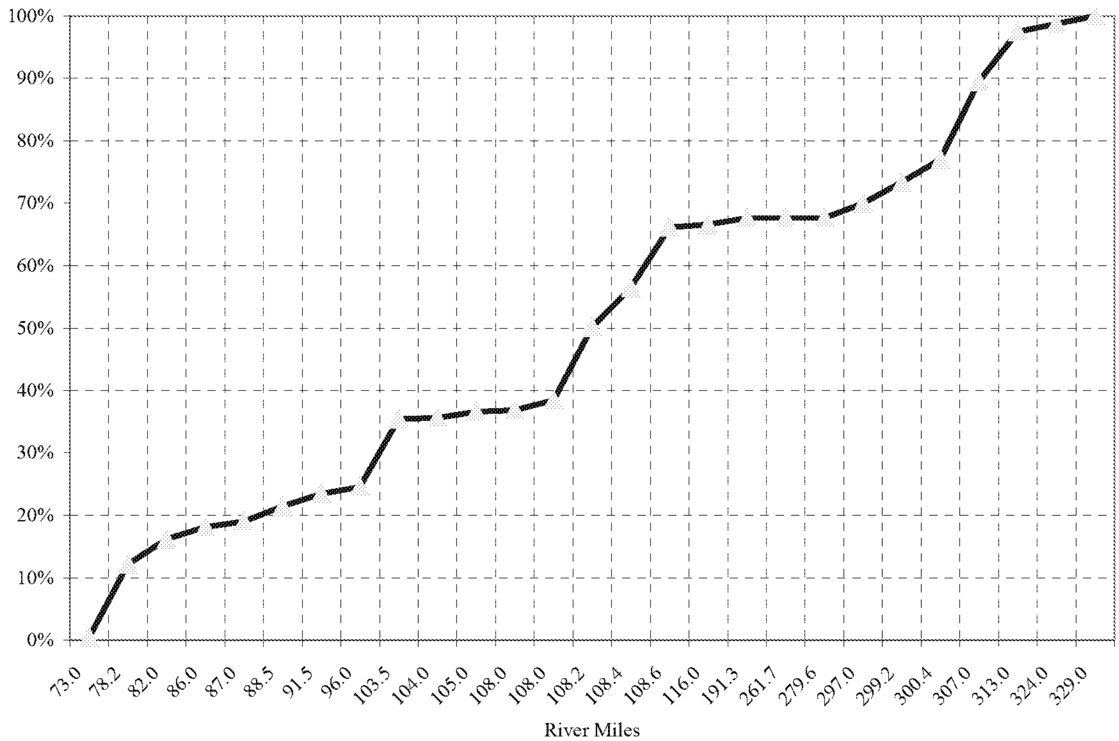

Figure 5.14 – Percentage volume of material along BWT Waterway.

Since this material is primarily sand, the most compatible application in coastal Louisiana would be barrier island restoration. The Sunflower Site is only 350 river miles from the Isles Dernieres coastal Louisiana barrier islands. According to the Timbalier project design template, approximately one mile of barrier island beach, dune, and marsh habitat was restored for every 2.1 mcy of material. Assuming similar material performance (1.28 to 1.0 cut to fill ratio), the readily available material from the BWT Waterway could be used to restore over 14 linear miles of coastal Louisiana barrier islands.

5.8 Compatibility of Imported Materials

Local borrow material is considered native; however, upstream sediment historically built the delta. Sample analysis of the Illinois sediment reveals that the materials are primarily silts and clays (Marlin 2002). Studies and field applications by Dr. John Marlin, Senior Scientist with the Waste Management and Research Center, Illinois Department of Natural Resources, indicate this material supports vigorous plant growth. The Illinois drainage basin is 80% agricultural and includes the Chicago metropolitan area; although volatile and semi-volatile organic compounds, and chlorinated pesticides were usually not detected in samples (Marlin 2003). However, additional samples and chemical analyses would be needed to determine the levels of polycyclic aromatic hydrocarbons and metals, as metals were detected at 1.5 to 3 times higher than background levels in native Illinois topsoil (Marlin 2003). This material would be suitable for marsh creation and/or nourishment assuming acceptable contaminant results.

MKARNS sediment varies in size along the river with an overall median particle size (d_{50}) of 0.80 mm based upon 214 samples (USACE SWL 2005). Materials in the lower portion of the system are finer grained than the upper reaches. The average d_{50} from RMs 50.3 to 186.4 is less than 0.60 mm. In comparison, the front face of Louisiana's barrier islands are composed of sand and the main body consists of fine sediments and sand (Thomson et al. 2004). Native characteristics of some of the Isle Dernieres and Timbalier barrier islands are shown in Table 5.3.

Table 5.3 - Coastal Louisiana barrier island median particle sizes.

Island	Native Beach Material (d_{50mm})
East	.16(1)
Timbalier (dune)	.187 to .196(3)
Trinity	.17(1)
Raccoon	.14(4)
Whiskey	.20(2)
Notes: (1) CPE 2005, (2) DMJM 2005, (3) TBS 2002, (4) Thomson et al. 2004	

The MKARNS material is larger than the existing barrier island sands. Ideally, size and distribution of borrow sand should match native beach materials (USACE CEM 2002). However, a beach can better withstand erosive forces when the particle size of the borrow material is coarser (USACE CEM 2002). Coarser particles have a lower loss rate than fine particles because they are more resistant to wave action and wind transport, reducing nourishment requirements (USACE 1984). Coarser fill is expected to provide a steeper beach, and very coarse materials will be stable under both normal and storm conditions (USACE 1984). Issues with coarser material are related to recreational usage and wildlife habitat (USACE 1984). The MKARNS material also exceeds the typical size range of temperate beach zones where the d_{50} lies between 0.15 and 0.40 mm (USACE CEM 2002). The USACE report indicated "contaminants in the sample were elevated above acceptable levels" at some of the dredge sites and additional analysis would be required (USACE SWL 2005). However, at a majority of the sites, material "is composed primarily of sand and gravel and is most likely to be free of contaminants" (USACE SWL 2005). Apart from the chemical composition, the larger size of the MKARNS sediment would limit its application in coastal Louisiana.

Dredged material from ten of the BWT waterway upland sites were sampled and characterized by the U. S. Department of the Interior, U.S. Bureau of Mines, Tuscaloosa Research Center in 1995. Results indicate that the materials are clean quartz sand and gravel having few impurities (Smith 1995). The report further states that "the material consists of 4.37% coarse aggregate, 94.66% reactive aggregate, i.e. deleterious organic fine aggregate, and 0.97% undersize (BOM 1995, SAM 2005). In addition to physical testing, samples were also subjected to the Toxic Characteristic Leachate Procedure (TCLP) in order to confirm or deny the presence of heavy metals. TCLP results indicate that no samples were characterized as a hazardous waste (BOM 1995, SAM 2005). A September 2001 report prepared for USACE, Mobile District, analyzed four additional samples of BWT materials at the following locations:

- surface of Buena Vista 2 site;
- a depth of 1.5 ft. at the Buena Vista 2 site;
- Bald Bar/Big Sand; and,
- North Star Wreck (Thompson 2001).

This report concluded that certain BWT dredged materials may be suitable for placement in the coastal environment (Thompson 2001). Physical testing revealed the d_{50} ranged from 0.16 mm to 0.26 mm, and the material ranged from 89.4% to 95.9% fine sand (Thompson 2001). Additional physical testing of the BWT waterway materials was conducted a third time in May 2004 and gradation analysis reports were furnished by the USACE, Mobile District. Particle size distribution curves were developed to determine the d_{50} of the material. Results of the particle size distribution analysis are shown in Table 5.4.

Table 5.4 – Median diameter (mm) of BWT waterway dredged materials.

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
2004 d_{50} (mm)	0.30	0.30	0.30	0.35	0.30

The d_{50} of the BWT materials varies by location (RM) with the larger grain size material in storage locations further upstream. This is not unexpected as larger, heavier materials would fall out of suspension first and the lighter, smaller materials would be transported further downstream. A comparison of material characteristics from various borrow sources for CWPPRA projects and other potential imported sediment options (Mississippi River RM 35 to RM 20 and the BWT waterway) is shown in Table 5.5.

Table 5.5 – Borrow source characteristics for CWPPRA projects and the BWT sand.

Borrow Source/Project	delineated quantity (cy)	material characteristics	$d_{50\ mm}$
Ship Shoal (Block 88) (TE-47) borrow area	17,300,000[1]	Fine grained sand (SP)	.20[1]
Little Pass (TE-40) borrow area	12,700,000	> 80% sand	.11[3]
Wine Island Pass offshore (TE-37) borrow area	5,421,000[3]	87.26% sand, 12.74% silt	.11[3]
Quatre Bayou Pass (BA-35) 10 miles offshore	7,900,000[6]	Fine grained sand	.136[6]
		Mud overburden	.076[6]
Quatre Bayou Pass (BA-38) 2 miles offshore	3,669,800[7]	Fine sand (.08 to .18 mm)	.13[7]
Sandy Point (BA-38)	3,619,500	Fine sand (.02 to .18 mm)	.10[7]
MS River, RM 35 to RM-20	Unknown	Sands	.21[5]
BWT Waterway	30,000,000[2]	94%[4] sand and 89.4% to 95.9% fine sand[8]	.18[8] - .31[4]
Notes: 1. DMJM 2005 , 2. Horn 2005, 3. CPE 2005, 4. BOM 1995 , 5. CPE 2004, 6. SJB 2005, 7. Brass 2003, 8. Thompson 2001			

The BWT sand has a larger size than any of the borrow sources used to replenish the Louisiana barrier islands to date. Some BWT material is larger than the native island materials, but unlike the MKARNS sand, it is still within the typical size range of temperate beach zones (USACE CEM 2002). Size is not an obstacle to using the BWT sands to restore coastal Louisiana barrier islands.

Aesthetics is important for beach restoration. Samples taken from four BWT locations were visually compared to samples of the Little Pass borrow materials used in the restoration of Timbalier Island, revealing that color of the BWT sand is beige in contrast to the light gray material dredged from Little Pass and placed on Timbalier. The color of samples from the BWT Buena Vista 2 site is very pale brown; light yellow brown for

Bald Bar/Big Sand; and very pale brown at the North Star Wreck site (Thompson 2001). A high energy environment at a coastal area may result in color changes over time (Thompson 2001). Indeed, the material placed on Timbalier Island has become much lighter in color after continued exposure to the sun and ocean spray. Borrow sediments darkened by organic material, or reddened by oxidized clay minerals, are known to quickly bleach from sun exposure becoming a more natural beach color (USACE 1984).

With the exception of Grand Isle, coastal Louisiana barrier islands are uninhabited. If concerns are raised over the size, color, and/or compatibility of using BWT material, it is recommended that a demonstration project be conducted involving filling abandoned oil field canals on the barrier islands and monitoring the results (Penland 2005). BWT sand could also be placed as an unconfined beach fill in front of the barrier island dune, or in the deeper waters behind the island back marsh areas providing a support platform for the island to roll onto instead of losing transient, native material into deep waters. Oil companies may be interested in participating in a program as part of their mitigation requirements. Substantial environmental and economic benefits and cost savings could result with such a partnering program.

5.9 Cost Comparison of Materials

Dredging an inland borrow source based upon variable placement is $2.75 per cubic yard according to the CWPPRA Engineering Work Group PPL 15 Project Cost Summary spreadsheet. As stated on the spreadsheet "costs and rates are extremely dependant upon specific site and project conditions". For example, the East Marsh Island (TV-21) marsh creation project as approved in 2004 by the CWPPRA Engineering Work Group, estimated costs for dredged material at $4.00 per cubic yard for a nearby source.

5.10 Transporting Sediments by Barge

Barge rates are not published in tariff form but they are negotiated between shippers and barge line operators (MVR 1996). Negotiated rates are based upon individual costs and market conditions, including equipment supply and demand, and rates are known to vary among barge lines, regionally, and time of year (MVR 1996). MKARNS lock chambers were configured to accommodate eight-barge tows for a single lockage, or 15-barge tows using a double lockage (USACE SWL 2005). A six to eight barge tow is typical on the BWT waterway (Horn 2005). In order to overcome the variability in tow sizes, transportation segments were established for each sediment source and typical tow sizes designated. This standardization will enable a relative cost comparison for each sediment alternative. For example, a conservative, average tow size of 35 barges was used to estimate costs of transportation on the Mississippi River segments. As previously discussed, towboats used on the middle Mississippi River range from 5,600 to 6,000 hp, and 5,600 to 10,500 hp on the lower Mississippi River (Petersen 1997). Therefore, a 7,000 hp towboat was selected for the Mississippi River travel segment. A 4,400 hp towboat was used on the other segments. The number of barges and towboats used for each segment is presented in Table 5.6.

Table 5.6 – Tow characteristics selected for travel segments.

Travel Segment	Tow size (barges)	Towboat (hp)
Midpoint Illinois Waterway to confluence MS River	15	4,400
Mississippi River to New Orleans	35	7,000
Midpoint of MKARNS to confluence MS River	8 and 15	4,400
Midpoint of BWT to Mobile	6	4,400
Mobile to New Orleans	6	4,400
New Orleans to Typical CWPPRA project location	6	4,400

USACE surveys vessel owners and operators to develop daily operating costs for barges and towboats for the Mississippi River System (EGM 2004). These values are then used by the USACE in their studies to evaluate potential costs of navigation improvements (EGM 2004). The USACE Economic Guidance Memorandum (EGM), 05-06, Shallow Draft Vessels Operating Costs, Fiscal Year 2004 was used as a basis to estimate costs to import sediment. The EGM daily cost for a hopper barge was rounded up from $93.30 per day to $95.00 per day. A 7,000 hp towboat EGM cost ranges from $14,068.95 for hipower use to $11,367.36 for actual power use, based upon an average high sulfur diesel fuel cost from 2000 to 2003 of $1.166 (EGM 2004). The cost for U.S. No. 2 diesel fuel as of September 2005 was $1.93 (DOE 2005). Therefore, fuel costs for the towboats were doubled, increasing the cost for a 7,000 hp towboat to $21,706.25 for hipower use to $16,339.70 for actual power use. For the economic comparison, an average cost per day for the 7,000 hp towboat of $19,000 was used. The same methodology was used to estimate the daily cost of 4,400 hp towboat as $12,500 per day.

Loading and unloading materials at the project location would be an additional charge generally $2.00 to 3.00 per cubic yard depending upon the method, and are not included.

5.11 Costs to Import Illinois Sediment

Charges for towboats and barges are listed as a daily rate, therefore travel time must be determined to estimate costs. The travel distance from midpoint of the Illinois Waterway to New Orleans is approximately 1,248 river miles, plus an additional 108 river miles to the typical CWPPRA project location, for a total one-way travel distance of 1,356 river miles. Travel segments for the Illinois Waterway are represented in Figure 5.15.

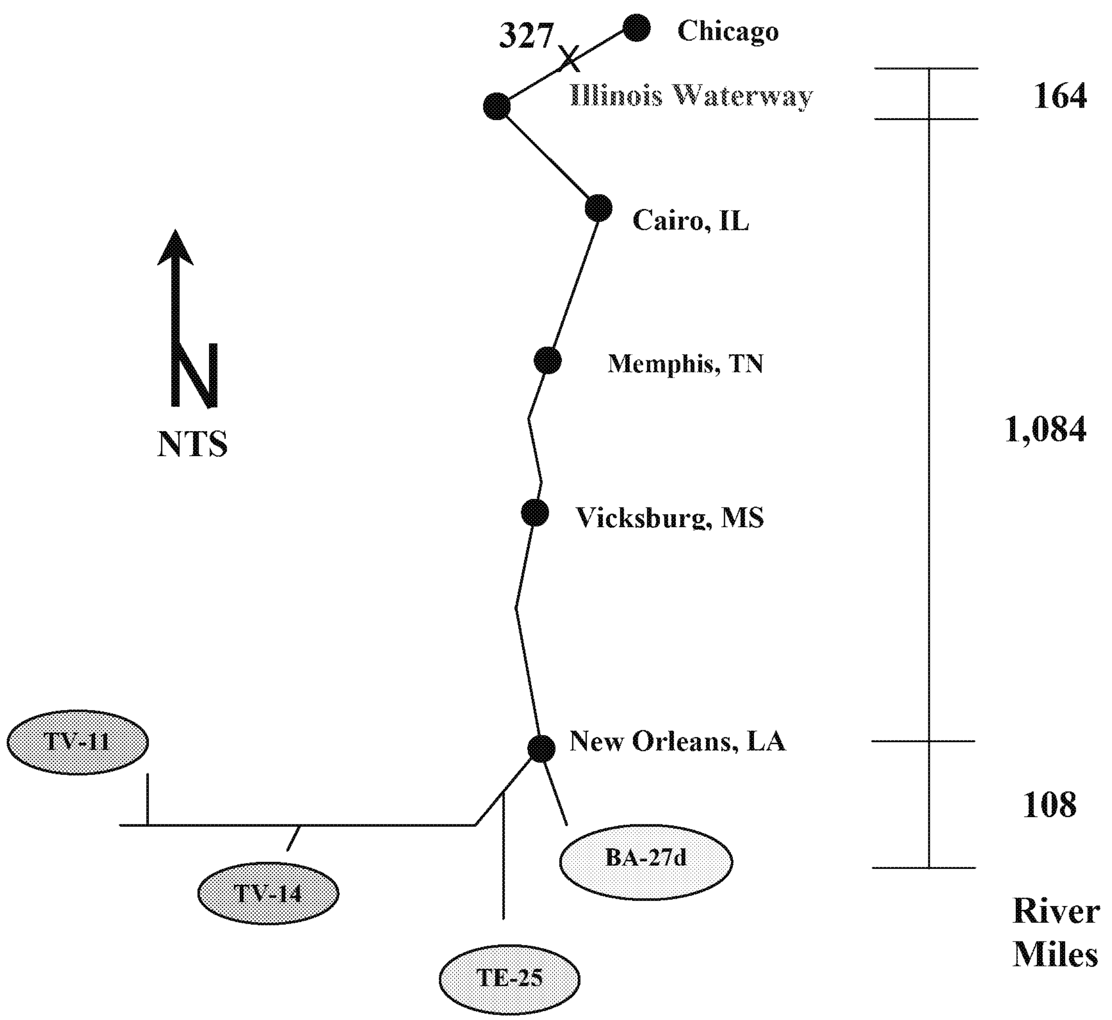

Figure 5.15 – Travel segments from Illinois Waterway midpoint to typical CWPPRA project location (not to scale).

Sediment would be transported in 1,500 ton capacity open hopper barges, requiring 100,000 barge loads to move the materials. The trip would take approximately 16 days one-way, based upon an average speed of 4 miles per hour, and assuming no major delays. Based upon the above assumptions, it would cost approximately $27,739 for each barge of Illinois material, or $23.54 per cubic yard, based upon roundtrip. Eliminating the empty return trip reduces costs 50%. This estimate per cubic yard for importing Illinois sediment currently exceeds the costs of local materials typically used for CWPPRA marsh creation previously cited as $2.75 to $4.00 per cubic yard. The estimated costs are adjusted to account for recent fuel price increases however the CWPPRA PPL 15 Project Cost Summary spreadsheet used to derive the typical costs do not. Without adjusting for fuel increases, the EGM 2004 based cost to import Illinois sediment drops 29%; to $16.73 per cubic yard (roundtrip), and $19,719 per barge. This cost per cubic yard is four to six times greater than the present CWPPRA cost per cubic yard using adjacent borrow material. Details of the transportation cost analysis for the Illinois material are presented in Table 5.7.

Table 5.7 – Cost analysis of transporting Illinois material to Louisiana.

Illinois Sediment	Peoria Lakes location					
117,831,893	cy					
150,000,000	tons					
Illinois Waterway Segment	**RM**	**Mississippi River Segment**	**RM**	**From New Orleans to project**	**RM**	**Total**
Ill Waterway (midpoint)	163.5	MS River confluence	23	to typical project location	108	
		St. Louis	15			
			62			
		Cairo, IL	118			
		Memphis, TN	226			
			129			
		Greensville, MS	62			
		Vicksburg, MS	100			
			133			
		Baton Rouge, LA	75			
		New Orleans, LA	141			
subtotal	164	subtotal	1,084	subtotal	108	
One way travel distance (1)	**164**		**1,084**		**108**	1,356
One-way travel time (days)	**2.00**		**12.00**		**2.00**	16
Number of barges	**100,000**		**100,000**		**100,000**	100,000
Cost of barges (2)	$ 19,000,000		$ 114,000,000		$ 19,000,000	$ 152,000,000
Number of tugs - 15 barge tow	6,667	35 barge tow (5)	2,858	6 barge tow	16,667	
Cost of towboats (3) 4,400 hp	$ 166,675,000	7,000 hp towboat	$ 651,624,000	4,400 hp towboat	$ 416,675,000	$ 1,234,974,000
One-way estimated cost	$ 185,675,000		$ 765,624,000		$ 435,675,000	$ 1,386,974,000
Round trip cost (4)	$ 371,350,000		$ 1,531,248,000		$ 871,350,000	$ 2,773,948,000
cost per cubic yard (RT)	$ 3.15		$ 13.00		$ 7.39	$ 23.54
cost per cubic yard (oneway)	$ 1.58		$ 6.50		$ 3.70	$ 11.77
cost per barge	$ 3,714		$ 15,312		$ 8,714	$ 27,739

Notes:
(1) assumes 4 mph speed
(2) $95 per day operating cost (based upon USACE 2004 estimate of $93.30)
(3) $12,500 per day operating cost (based upon USACE 2004 estimate 4,400 hp use doubling the fuel costs)
(4) return trip (empty) is the same cost as original trip
(5) representative tow size on Lower Mississippi River (Petersen 1997)
(6) $19,000 per day operating cost (based upon USACE 2004 estimate 7,000 hp use doubling the fuel costs)

5.12 Costs to Import MKARNS sediment

The midpoint location of the MKARNS dredging, approximately RM 285, was used as the starting point for estimating costs of transporting the dredged material to coastal Louisiana. One-way travel time is 11 days, for the 904 mile distance. Travel segments for the MKARNS are represented in Figure 5.16.

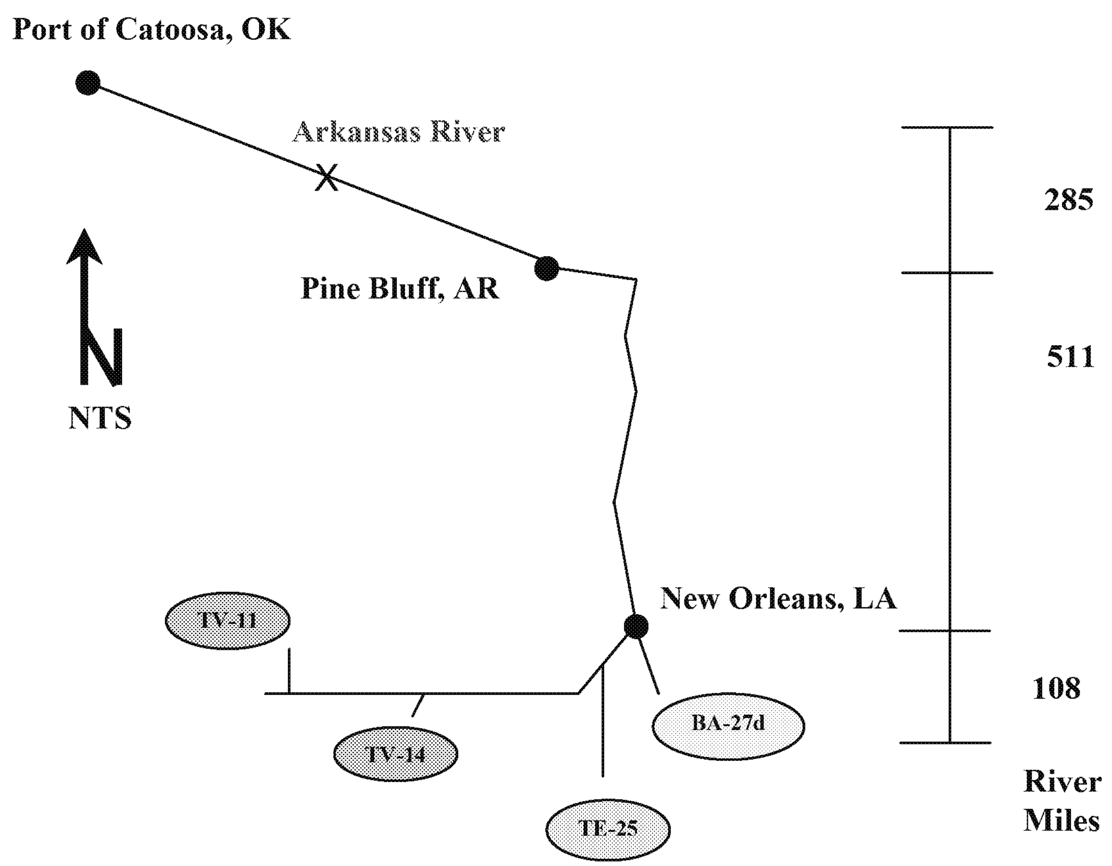

Figure 5.16 – Travel segments from the MKARNS midpoint to typical CWPPRA project location (not to scale).

Using EGM unit costs escalated for fuel prices, transportation costs for the various combinations of eight-barge tows versus 15-barge tows, and dead-head return trips versus no cost return trips are:

- $22.83 per cubic yard for eight-barge tows, and dead-head return trip;
- $19.04 per cubic yard for 15-barge tows, and dead-head return trip;
- $11.42 per cubic yard for eight-barge tows, eliminating the return trip; and
- $ 9.52 per cubic yard for 15 barge tows, eliminating the return trip.

The costs to transport the Arkansas River dredged material to Louisiana are slightly more competitive than importing the Illinois sediment. The transportation cost analysis for the MKARNS material is presented in Table 5.8.

Table 5.8 - Cost analysis of transporting MKARNS sediment.

Arkansas River - construction	**mid-point of dredged storage**					
10,985,340	cy					
14,280,942	tons(10)					
Arkansas River Segment		**Mississippi River Segment**		**From New Orleans to Project**		**TOTAL**
midpoint of dredged storage	285	MS River to Vicksburg	162	to typical project	108	
		Vicksburg to Baton Rouge	208			
		Baton Rouge to New Orleans	141			
subtotal	285	subtotal	511	subtotal	108	
One-way travel distance(1)	285		511		108	904
One-way travel time (days)	3.00		6.00		2.00	11
single lockage						
Number of barges(8)	9,521		9,521		9,521	
Cost of barges(4)	$ 2,713,485		$ 5,426,970		$ 1,808,990	$ 9,949,445
Number of tugs(9) 8 barge tow	1,191	35 barge tow(5)	273	6 barge tow	1,587	
Cost of towboats 4,400 hp(5)	$ 44,662,500	7,000 hp towboat(5)	$ 31,122,000	4,400 hp towboat(5)	$ 39,675,000	$ 115,459,500
One-way estimated cost	$ 47,375,985		$ 36,548,970		$ 41,483,990	$ 125,408,945
Round trip cost(4)	$ 94,751,970		$ 73,097,940		$ 82,967,980	$ 250,817,890
cost per mile bi restor.(7)	$ 6,602,925		$ 5,093,933		$ 5,781,741	$ 17,478,599
mat'l cost per cubic yard	$ 8.63		$ 6.65		$ 7.55	$ 22.83
cost per cubic yard (oneway)	$ 4.31		$ 3.33		$ 3.78	$ 11.42
cost per barge	$ 9,952		$ 7,678		$ 8,714	$ 26,344
double lockage						
Number of barges(8)	9,521		9,521		9,521	
Cost of barges(2)	$ 2,713,485		$ 5,426,970		$ 1,808,990	$ 9,949,445
Number of tugs(10) 15 barge tow	635	35 barge tow(5)	273	6 barge tow	1,587	
Cost of towboats 4,400 hp(5)	$ 23,812,500	7,000 hp towboat(6)	$ 31,122,000	4,400 hp towboat(5)	$ 39,675,000	$ 94,609,500
One-way estimated cost	$ 26,525,985		$ 36,548,970		$ 41,483,990	$ 104,558,945
Round trip cost(6)	$ 53,051,970		$ 73,097,940		$ 82,967,980	$ 209,117,890
cost per mile bi restor.(7)	$ 3,697,001		$ 5,093,933		$ 5,781,741	$ 14,572,675
mat'l cost per cubic yard	$ 4.83		$ 6.65		$ 7.55	$ 19.04
cost per cubic yard (oneway)	$ 2.41		$ 3.33		$ 3.78	$ 9.52
cost per barge	$ 5,572		$ 7,678		$ 8,714	$ 21,964
Applying $30,300,000 cost share (single lockage)		**Applying $30,300,000 cost share (double lockage)**				
One-way estimated cost	$ 95,108,945	One-way estimated cost	$ 74,258,945			
Round trip cost(6)	$ 220,517,890	Round trip cost(6)	$178,817,890			
cost per mile bi restor.(7)	$ 15,367,100	cost per mile bi restor.(7)	$ 12,461,177			
mat'l cost per cubic yard	$ 20.07	mat'l cost per cubic yard	$ 16.28			
cost per cubic yard (oneway)	$ 8.66	cost per cubic yard (oneway)	$ 6.76			
cost per barge	$ 23,161	cost per barge	$ 18,781			

Notes:

(1) assumes 4 mph speed (2) $95 per day operating cost (based upon USACE 2004 estimate of $93.30)

(3) $12,500 per day operating cost (based upon USACE 2004 estimate 4,400 hp use doubling the fuel costs)

(4) return trip (empty) is the same cost as original trip (5) representative tow size on Lower Mississippi River (Petersen 1997)

(6) $19,000 per day operating cost (based upon USACE 2004 estimate 7,000 hp use doubling the fuel costs)

(7) based upon Timbalier project template (4.6 MCY incl 200,000 storm movement, to restore 2.2 miles)

(8) tons per cy conversion (1.3) per USACE SWL 2005 (9) based upon an 8 barge flotilla (USACE SWL 2005)

(10) based upon a 15 barge flotilla - double lockage (USACE SWL 2005)

5.13 Costs to Import BWT sediment

The median distance of the BWT storage sites was used to estimate transportation logistics and costs for moving this material to Louisiana. Based upon a 4 mph travel speed, the sand has an approximate four day travel time from the BWT median location (BWT RM 108) to a typical CWPPRA project location, coincidentally established as 108 river miles from New Orleans in previous analyses. Travel segments for the BWT River System are represented in Figure 5.17.

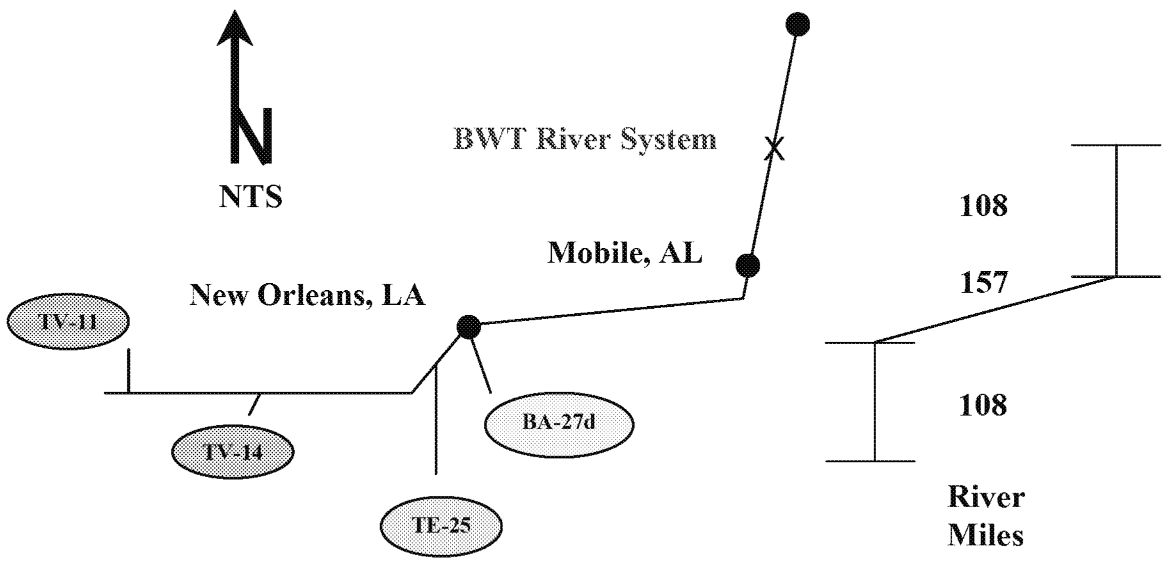

Figure 5.17 – Travel segments from the BWT midpoint to typical CWPPRA project location (not to scale).

The BWT travel distance is nearly one-fourth of the Illinois sediment mileage. Cost to transport the BWT sand to Louisiana is significantly less than importing the Illinois or MKARNS materials and more competitive to the local borrow prices. The transportation cost analysis for the BWT sand is presented in Table 5.9.

Table 5.9 - Cost analysis of transporting BWT sand.

30,000,000	cy			
BWT Waterway				
36,450,000	tons[2]			
Midpoint BWT to CWPPRA Project			**Mobile to CWPPRA Project**	
	RM		**RM**	
midpoint at RM 108	108		0	
Mobile, AL to Mobile Bay	29		0	
Mobile Bay to Pascagoula	29		29	
Pascagoula to Gulfport	31		31	
Gulfport to New Orleans	68		68	
subtotal	265		128	
to typical project location	108		108	
One-way travel distance[1]	**373**		**236**	
One-way travel time (days)	**4.00**		**3.00**	
Number of barges[2]	**24,300**		**24,300**	
Cost of barges[4]	**$ 9,234,000**		**$ 6,925,500**	
Number of tugs[3] 4,400 hp	**4,050**		**4,050**	
Cost of towboats[5]	**$ 206,550,000**		**$ 154,912,500**	
One-way estimated cost	**$ 215,784,000**		**$ 161,838,000**	
Round trip cost [6]	**$ 431,568,000**		**$ 323,676,000**	
cost per mile bi restor.[7]	**$ 15,037,213**		**$ 11,277,909**	
mat'l cost per cubic yard	**$ 14.39**		**$ 10.79**	
cost per cubic yard (oneway)	**$ 7.19**		**$ 5.39**	
cost per barge	**$ 17,760.00**		**$ 13,320.00**	
Notes:				
(1) assumes 4 mph speed				
(2) tons per cy conversion (1.215) per USACE bid specifications				
(3) based upon a 6 barge flotilla				
(4) $95 per day operating cost (based upon USACE 2004 estimate)				
(5) $12,750 per day operating cost (based upon USACE 2004 estimate double fuel costs)				
(6) return trip (empty) is the same cost as original trip				
(7) based upon Timbalier project template (4.6 MCY to restore 2.2 miles)				

Cost per cubic yard of dredged materials varies considerably due to the availability of equipment, contractor workload, project location, project specifics, and source location (Petersen 1997). For example, the line item award for the dune and beach fill component of the Chaland Headland Restoration (BA-38) Project was $5.55 per cubic yard to place 1,792,200 cubic yards of offshore material (Williams 2005). The cost per cubic yard of dredged material for the Timbalier Island Dune and Marsh Restoration (TE-40) project, bid in spring 2004 and completed January 2005, was $2.47. These awards took place prior to Hurricanes Katrina and Rita. The Ship Shoal Whiskey Island West Flank Restoration (TE-47) barrier island project recently completed the CWPPRA engineering and design phase. The design engineer estimated the cost to dredge Ship Shoal sands for the TE-47 project to be $5.50 per cubic yard (DMJM 2005).

In October 2004, the CWPPRA Engineering work group projected the costs at $11.71 per cubic yard to use sand dredged from the Mississippi River to restore Scofield Island. The project's federal sponsor contracted for a technical assessment to investigate the potential for mining river sand sources. Results of the assessment identified costs ranging from $6.06 to $12.04 per cubic yard (CPE 2004).

Using the comparable cost approach (based upon recent CWPPRA projects), moving sand from the BWT to coastal Louisiana is competitive with CWPPRA projects recently awarded (BA-38) or planned (TE-47 and BA-40). The costs of using various borrow sources are summarized in Table 5.10.

Table 5.10 – Costs of source materials for recent CWPPRA barrier island restoration projects.

Project	Cost (cy)	Borrow Source	Quantity (cy)
Ship ShoalWhiskey Island West Flank (TE-47)	$ 5.50	Ship Shoal	4,000,000
Riverine Sand Mining/Scofield Island Restoration (BA-40)	$ 9.05[1]	Mississippi River sand	2,500,000
Timbalier (TE-40)	$ 2.47[2]	Little Pass	4,600,000
Chaland Headland Restoration (BA-38)	$ 5.55[2]	Quatre Bayou Pass	1,792,200
New Cut Barrier Island and Marsh Restoration (TE-37)	$7.47[2]	Wine Island Pass	2,500,000
Notes: (1) Price is an average value of the range developed by CPE in 2004. (2) Actual awards.			

5.14 Ways to Reduce Costs

A shipper's association can be used to pool volumes and negotiate volume discounts (AISA 2005). Additional economic savings could result in working with the vessel owners and operators and/or the shipper's association in establishing a transportation schedule during off-peak times and perhaps sharing towboat usage with other tows. Costs are based upon a roundtrip, assuming the barges would be empty on their return trip. Arrangements to eliminate the "deadhead" return could reduce the transportation costs by up to one-half.

The price per cubic yard is highly sensitive to the number of barges in the flotilla, which dictates the number of towboats required since the towboats represent the largest portion of the daily expense (up to 200 times the cost of a hopper barge). Increasing the size of the tow to 48 barges on the Mississippi River segment for the Illinois sediment reduces the roundtrip cost approximately 12.7% or $24,210 per barge and $20.55 per cubic yard. These efforts would make importing the Illinois material more cost competitive.

Dredged material is usually sampled and characterized which would reduce CWPPRA project costs associated with material uncertainty. Knowing the chemical/physical characteristics helps ensure that the dredged material is used appropriately and strategically placed. Fine grained materials would be directed towards marsh creation/restoration, and sandy material would be used for barrier island restoration. Sandy material could also be used as a foundation fill for marsh creation/restoration, lessening initial water depths and firmly supporting placement of silts and clays as the upper layer to ensure vegetative colonization.

Construction of dredge disposal areas for deepening the MKARNS would cost an estimated $30.3 million (USACE SWL 2005). Environmental mitigation to compensate for the adverse terrestrial and aquatic impacts over the 50-year project life would cost an additional $11.6 million (USACE SWL 2005). An economic and environmental synergy is possible if the USACE eliminates construction of the dredge disposal areas ($30.3 million) and the associated environmental mitigation ($11.6 million) and alternatively augments the net cost of transporting the sediment to Louisiana. In addition, adverse terrestrial impacts to 302 acres of forested habitat and 390 acres of grassland habitat from the new dredged material sites in Oklahoma would be avoided. Applying the $30.3 million towards the cost of transporting the material to Louisiana results in the following costs:

- $20.07 per cubic yard for eight-barge tows, and dead-head return trip;

- $16.28 per cubic yard for 15-barge tows, and dead-head return trip;
- $ 8.66 per cubic yard for eight-barge tows, eliminating the return trip; and
- $ 6.76 per cubic yard for 15 barge tows, eliminating the return trip.

Further cost reductions result by applying the $11.6 million to be used in compensation for adverse terrestrial and aquatic impacts. Cost scenarios of transporting dredged material associated with increasing the depth of the MKARNS to 12 ft. are presented in Table 5.11.

Table 5.11 – Benefits of applying mitigation costs to supplement transporting Arkansas River dredged material.

	8-barge tow cost/cubic yard 2005	15-barge tow cost/cubic yard 2005
Round trip	$22.83	$19.04
One-way	$11.42	$ 9.52
Round trip applying $41.9 M credit	$19.02	$15.22
One way trip applying $41.9 M credit	$ 7.60	$ 5.70

Various options have been discussed for restoring much needed dredged material storage capacity along the BWT waterway. In 2005, the Mobile District advertised a contract to remove and dispose of sand located at the Sunflower Bar upland site at Mile 78, BWT River System (SAM 2005). This contract involved removal of 300,000 to 1,500,000 cubic yards of material in one base year and at least 200,000 cubic yards in an additional option year (SAM 2005). Although the contract was not awarded, the need still exists to restore storage capacity.

In the contract solicitation, the contractor was required to remove the material and transport it to Mobile Bay, but the solicitation did not specify the end use of the sand (SAM 2005). Once the material was removed, it became the property of the Contractor. Destination or reuse of the sand was mandated to be in an area which had received proper environmental clearances (SAM 2005). Although this contract was not awarded, it demonstrates the potential that exists for the CWPPRA program to work with the USACE, Mobile District, to beneficially use their material for coastal Louisiana restoration projects. Instead of paying for removal and transport of the sand from the BWT locations, accepting the material at Mobile would reduce the costs per cubic yard by over 31%, as presented in Table 5.12. The CWPPRA project would also avoid the costs for mobilization and dredging. Cost savings accrue due to reducing the transport distance by approximately 137 river miles (108 miles from BWT midpoint plus 29 miles to Mobile Bay) and reducing the total travel trip time by one day, as shown in Table 5.12.

Table 5.12 – Cost benefits of accepting BWT material at Mobile.

	BWT to Project 2005[5]	**Mobile Bay to Project 2005**[5]
One-way travel distance[1]	373	236
One-way travel time[1] (days)	4	3
Number of barges[2]	24,300	24,300
Cost of barges[4]	$9,234,000	$6,926,070
Number of tugs[3]	4,050	4,050
Cost of towboats[5]	$206,550,000	$154,912,500
One-way cost	$215,784,000	$161,838,000
Round trip cost [6]	$431,568,000	$323,676,000
Cost/mile BI restoration [7]	$ 15,037,213	$11,277,909
Material cost/cy (roundtrip)	$14.39	$10.79
Material cost/cy (one-way)	$7.19	$5.40
Cost per barge	$17,760	$13,320
Notes: (1) assumes 4 mph speed, (2) tons per cy conversion (1.215) per USACE bid specifications, (3) based upon a 6 barge flotilla, (4) $95 per day operating cost (based upon USACE 2004 EGM estimate of $93.30), (5) $12,750 per day operating cost (based upon USACE 2004 EGM estimate, double fuel costs), (6) return trip (empty) is the same cost as original trip, (7) based upon Timbalier Island (TE-40) template (4.6 mcy dredged incl 200,000 cy storm movement, to restore 2.2 miles)		

The costs per cubic yard for importing the BWT sand listed in Table 5.12 do not include associated project costs such as any delay time in transit, mobilization, loading and offloading the material. Inexpensive conventional means could be used to harvest this material. A conveyor system could load the material directly into barges able to tie up to the adjacent bank where a navigable depth of nine ft. is available (Horn 2005). During a pre-bid site for the proposed removal contract, one contractor proposed using three sets of barges, each having a four-barge tow, to load/unload/transport the material.

As one set of barges was loading, another set could be in transit, while the third set is unloading at the destination (Horn 2005). Due to the navigability of the adjacent waterway, a number of different removal methodologies and alternatives would be possible depending upon contractor resources and the availability of equipment, number of barges, etc.

Cost savings would result by partnering with the USACE and avoiding the costs of loading the material from the BWT borrow source and avoiding any associated wait time of the barges and towboats during loading. The lower cost per cubic yard is a direct result of reducing the transportation distance. This confirms the need for strategic CWPPRA project planning of barrier island restoration projects and the associated borrow sources. It is recommended that the BWT materials be placed in the eastern portion of the Louisiana coast, while reserving the limited, offshore materials for the islands further west.

5.15 Environmental Benefits of Importing Materials

The Little Vermilion Bay Sediment Trapping Project (TV-12) would have benefited greatly from barging in sediment. The project is located in the northwest corner of Vermilion Bay, 3.75 miles southwest of Intracoastal City and adjacent to the Freshwater Bayou Canal. Approximately 21,300 ft. of distributary canals were dredged in order to create 33 acres of terraces (Aucoin TV-12 2002). Freshwater Bayou Canal is a navigable waterway maintained by the USACE, New Orleans District, to a depth of 12 ft. and width of 125 ft. connecting the GIWW to the Gulf of Mexico. By barging in sediments to create terraces, the process of building land and offsetting effects of subsidence and rise in sea level, mimics the historical natural processes of sediment placement and deposition. In addition to completing the project, using sediment brought in by barge would have eliminated dedicated dredging of local waterbottoms minimizing disruption to the local environment; and, eliminated local air emissions and fuel consumption from the on-site dredging. Since dredged material must be removed regardless of its final disposition, transporting to where it can be used beneficially offsets the negative environmental impacts of dredged material storage or disposal at another location.

Removing sediments from the Illinois, MKARNS, and BWT systems and placing them in Louisiana benefits the environments in Illinois, Oklahoma, Alabama, and coastal Louisiana. For example, the USACE estimates that 302 acres of forested habitat and 390 acres of grassland habitat would be lost to dredged material storage sites as a result of deepening the MKARNS. Since the MKARNS was completed in 1971, some of the approved dredged material disposal sites have been filled to capacity and thus new disposal sites will be required to continue maintenance in the future (USACE SWL 2005). Capacity of the remaining disposal sites in Oklahoma will be filled in less than ten years (USACE SWL 2005). Transporting dredged material to Louisiana would benefit the environment in Oklahoma by avoiding the need for environmental mitigation, while rebuilding much needed land elevation in coastal Louisiana.

BWT upland storage areas are also filling up and they must be either emptied or the footprint of the storage locations enlarged. The lands used to contain the materials are typically leased from individual landowners. Expanding storage areas would bury and destroy hardwood habitat such as that shown in Figure 5.18. USACE, Mobile District, has already drafted an Environmental Impact Statement (EIS) for expanding the site into adjoining bottomland hardwood areas as a contingent measure for ensuring maintenance dredging can continue once the existing sites are completely full.

Figure 5.18 – Future dredged material storage site in bottomland hardwood area, expansion of Sunflower Site.

Using BWT dredged materials benefits two ecosystems by restoring coastal Louisiana and avoiding expansion of storage locations along the BWT waterway. This concept avoids exploiting one non-renewable resource for the benefit of another environment. Unlike the offshore sand sources, such as Ship Shoal, BWT dredged materials constitute a renewable resource. For example, the most recent estimate of average annual dredging quantity at the Sunflower location is 191,100 cubic yards (Horn 2005). An additional 18.9 mcy of material is also available in 35 sites located on the Tom-Tenn Waterway in Alabama and Mississippi (Gwin 2005).

Finding a suitable location from which to borrow material is difficult in the marine environment. The USGS is working with the University of New Orleans to integrate all available sediment resource data, including the usSEABED and LASEDS databases. However, the complex sediment relationships in coastal Louisiana require site-specific investigations to locate the submerged sand shoals that fringe the southern Louisiana coast (Kulp et al. 2005). The CWPPRA Barrier Island Adaptive Management Report recommended sediment resource management on a regional scale instead of the project-by-project methodology (Penland et al. 2003). Extensive data collection is required to locate and define offshore borrow areas including seismic, bathymetric, magnetometer and side scan sonar surveys, vibracore sampling and analysis, and cultural resources investigations. Submerged oil and gas infrastructure such as wells and pipelines, and other submerged materials or cultural resources like shipwrecks may pose an impediment or hazard to dredging. Offshore investigations take time and are expensive. For example, the 2005 geotechnical investigation to locate a suitable borrow area for the New

Cut Dune and Marsh Restoration Project (TE-37) cost over $350,000. Importing the BWT materials, or sandy materials from other sources, eliminates the need for the expensive geotechnical investigations of marine borrow areas. Furthermore, wave refraction modeling studies are usually conducted to determine any potential impacts of using marine borrow sites. By importing inland materials, borrow site modeling would not be required.

An added benefit of importing sediment compared to using local material is eliminating the local emissions from the dredge. In the Timbalier Island Dune and Marsh Restoration (TE-40) project, the Tom James operated for nearly six months to dredge 4.6 mcy. Large dredges also usually have a towboat to assist in their movement. The BWT and MKARNS will be dredged in order to maintain navigation regardless of whether or not the sediments are transported to Louisiana. Emission standards for marine engines are being phased in (EPA ES 2004) so transportation related emissions should decrease in the future.

Dredging offshore borrow sites is constrained by weather conditions and has adverse environmental impacts. Bad weather, particularly during the winter season, often halts dredging operations altogether (Herbich 2000). During construction of the Timbalier Island Dune and Marsh Restoration (TE-40) project from June 2004 to December 2004, two hurricanes and one tropical storm interfered with the dredging causing significant downtime as the dredge was moved inland for protection. Excavating marine aggregates disturbs the natural benthic biological community. Benthic recolonization may take several years and in some cases, the new community may not completely return to the pre-disturbed condition (Herbich 2000). Dredging may also impact Kemp's ridley turtle (Lepidochelys kempii), an endangered species that resides in coastal areas of the Gulf of Mexico (NMFS 2005). Turtles may be disturbed during the nesting season, which often coincides with most suitable times for dredging (Herbich 2000). Dredging operations affect the turtles not only by incidental take, but also by degrading or destroying their habitat (NMFS 2005).

Disturbed geologic materials have different engineering properties as compared to their undisturbed state (ERDC 2004). After fine-grained materials have been dredged, transported, and redeposited, their pre-dredged geotechnical properties may no longer be valid (ERDC 2004). Coarse-grained materials may revert to their original properties but may also undergo changes in grain size distribution (ERDC 2004). CWPPRA project features are designed based upon the pre-dredged geotechnical properties of the in-situ borrow material. Post-dredging changes in sediments may explain why some projects do not perform as expected, and quantity overruns or shortages encountered during construction. This uncertainty economically impacts the design, construction, and project results. Some of this uncertainty would be reduced when using well-characterized dredged material after dewatering and storage.

Coastal sand deposits identified for use on CWPPRA barrier island restoration projects may be underneath overburden materials inappropriate for building beaches and dunes. For example, over 3.6 mcy of clean sand within the Sandy Point borrow area identified for use in the Pelican Island Restoration project (BA-38-1) has over three mcy of mud overburden (Brass 2003). Similarly, the Quatre Bayou borrow site contains almost 3.7 mcy of clean sand situated under 8.3 mcy of mud overburden (Brass 2003). Overburden materials must be removed to access the clean sand but in some cases it may be used for marsh creation on the marsh platform portion of the restoration projects. Otherwise, it may have to be placed in open water disposal areas. Utilizing the BWT sand, or other imported sandy materials, avoids the impacts of both borrow source dredging and overburden disposal.

Vegetative plantings on barrier island restoration projects are often delayed to enable precipitation to leach sea water salts from dunes newly created from marine borrow material. At the Timbalier Island (TE-40) project, excessive salts from dredged marine sediments, combined with limited precipitation, interfered with successful establishment of the vegetative plantings in some areas (Bahlinger 2005). Sandy materials imported from freshwater sources allow immediate planting of vegetation, helping to retain the newly placed sands.

CWPPRA barrier island, sediment delivery, and sediment delivery/marsh creation projects have the longest project duration, typically six years from authorization. Delays often result from public objections to selected borrow sites. For example, the New Cut Dune and Marsh Restoration Project (TE-37), suffered a 1.5 year delay in starting construction due to objections over the borrow site originally selected. Perhaps barrier island projects could be completed faster by using BWT sand of known quantity and quality. No new testing or investigations would be required.

5.16 Issues with Importing and Placing Sediments

Possible negative impacts of importing sediments to restore coastal Louisiana include increased subsidence, real estate issues, cost, logistics, and environmental concerns such as impacts to waterbottoms, air emissions, and non-renewable resource consumption. However, these are all potential impacts of using in-situ and/or nearshore local sediments to restore marsh and rock for shoreline protection.

Added sediments could potentially increase subsidence by further consolidating subsurface foundation materials. Fault occurrence and movement have been suggested as causes of coastal Louisiana land submergence, and sediment loading could intensify the effect (Gagliano 2005). Morton has suggested that extensive hydrocarbon extraction has resulted in faulting, causing high rates of localized subsidence (Barras et al. 2004). Loading can also contribute to soil strength in the substratum (Kemp et al. 1999). Geotechnical investigations would be required to determine allowable placement heights and estimate impacts of the added weight on the project area. However, these types of investigations are already conducted for most types of CWPPRA projects. The design fill height could be selected to account for any additional settlement, subsidence, and rising sea level.

Legal issues such as obtaining easements from private landowners and compensating for oyster leases may present formidable obstacles to sediment importation and placement. Changes in land use and potential disruption in water-related activities including occupational and recreational fishing and hunting, and access to oil and gas facilities would also have to be addressed. Cultural resources exist in many areas and their presence may preclude site activities. These issues are not unique to importing and placing sediment and most CWPPRA projects must address at least one of these issues. Public education and coordination would assist in overcoming these concerns.

Although the local, inland dredged material unit cost is less than importing material, inland borrow costs do not reflect environmental benefits. Cost-benefit analysis alone does not value complex and diverse ecosystem functions (Ko et al. 2004). Recognizing this shortcoming, the USACE and State of Louisiana are using a risk-based analysis instead of the standard benefit-to-cost ratio to evaluate the Master Plan for coastal restoration and flood protection following Hurricanes Katrina and Rita. Using this methodology could revolutionize the way the USACE develops and analyzes projects (Russo 2006). With a limited annual budget, CWPPRA federal agencies need to re-examine their project develop processes and strive to develop partnerships to maximize restoration activities for the long term instead of focusing on short-term project cost.

Importing fill material should be viewed as an ongoing long-term process, because there are a limited number of vessels available for transportation and navigation has certain capacities. The current mind set that local borrow is acceptable to address land loss must be overcome in order to recognize the need for maximizing beneficial use and sediment importation. Land loss recovery by importing sediments by barge will require a dedicated effort, logistically and financially. Once again, partnership opportunities would facilitate an enduring commitment to this sustainable restoration methodology.

Restoring marshes with imported sediment will cover a much larger surface area than placing stone riprap along the shoreline. Short-term adverse impacts on the local environment are acknowledged; however, restoring open water areas adds critical land surface area. This restoration method reverses land loss and is the most effective and sustainable alternative in the long term. Barging material in to raise ground surface elevations allows strategic placement to take place and an opportunity to minimize impacts. Eliminating local borrow sources would also preserve those habitats. Once the material arrived at the project site, traditional placement methods such as slurry pipelines could be used to deliver the material. A demonstration project placing dredged material from the Illinois Waterway successfully used positive displacement pumps and conveyors to handle fine-grained materials with a high solids content (Marlin 2006, Marlin 2003). Mechanical methods could also be used for placing material to fill open water areas adjacent to the navigable waterways. An example project would be the open water areas behind the BA-26 project, adjacent to the GIWW. Not unlike the stone that is barged in from Missouri, Arkansas, Kentucky, and Tennessee, the upstream and nearby system sediments could also be delivered to coastal Louisiana for land building using existing navigable waterways. Louisiana is the geographical center of the GIWW, which extends from Brownsville, Texas to St. Marks Florida, then from Tarpon Springs, Florida southward 150 miles to Fort Myers (GIWW nd). Five USACE Districts maintain the GIWW to a depth of at least 12 ft. deep and a width of 125 ft., providing a protected passage and a link to the eastern seaboard via the Okeechobee Waterway and Atlantic Intracoastal Waterway (GIWW nd). BWT materials are in dry storage. Upon arrival, water at the site could be pumped into hopper barges to create a sand slurry for easy pumping; adding material, not additional water to the project location. A desirable land to water ratio, like that for the La Branche (PO-17) project, would ensure sufficient aquatic habitat. Rebuilding the land elevation, addressing subsidence and mitigating the effect of rising sea level, has long-term benefits that outweigh the temporary impacts to benthic organisms resulting from sediment placement.

Emissions would result from transporting the materials to coastal Louisiana and construction related activities. Transportation emissions result from towboats escorting the barges. The hours of operation method was selected to estimate emissions from the towboats. The available sediments are located adjacent to waterbodies so the median geographic location of the materials was determined in order to determine the distance in river miles to New Orleans. The location to a "typical" CWPPRA project from New Orleans was previously estimated to be 108 river miles. The average inland towboat speed of 4 mph (Rossetti and Nachtmann 2004) was used to determine the transit time (distance divided by the travel speed). Starcrest emission factors were used to estimate the emissions (Starcrest 2003). The estimated total emissions from importing sediment from the Illinois Waterway, MKARNS, and BWT are presented in Table 5.13.

Table 5.13 – Emissions from importing sediment for placement in coastal Louisiana.

	Emissions (tons)					
Sediment Location	PM 10	PM 2.5	Hydrocarbons	CO	NOx	SOx
Illinois Waterway	7,226	6,648	8,639	23,923	188,493	55,476
MKARNS Single lockage	678	625	811	2,243	17,659	5,198
Double lockage	532	490	636	1,758	13,841	4,074
BWT from midpt.	1,394	1,283	1,667	4,619	36,399	10,712
BWT from Mobile	882	812	1,055	2,922	23,030	6,778

Emissions are directly related to the material volume transported and distance. As expected, emissions from importing the 150 million tons of Illinois Waterway sediments exceed those expected from the MKARNS or BWT. A comparison of these emissions to the total PM 10 emissions for importing stone is shown in Table 5.14. Normalizing the PM 10 emissions on a volume basis reveals that the emissions per million tons of stone exceeds the PM 10 emissions for importing sediment by over 2.5 times. Importing the Illinois Waterway sediment adds substantially less PM 10 emissions per ton of material even though the distance traveled from Illinois is farther than stone. Recall the majority of the emissions associated with the use of stone result from quarrying and processing.

Table 5.14 – PM 10 emissions per million ton of material.

Material	Total Travel Distance (RM)	Quantity (million tons)	Total Emissions PM 10 (tons)	Emissions per Mton
Stone (with controls)	890	3.800	464	122.11
Stone (with controls)	890	5.700	690	121.05
Stone (with controls)	890	7.600	917	120.66
Stone (no controls)	890	3.800	635	167.11
Stone (no controls)	890	5.700	950	166.67
Stone (no controls)	890	7.600	1,266	166.58
Illinois Waterway sediment	1356	150.000	7,226	48.17
MKARNS (single lockage)	904	14.280	678	47.48
MKARNS (double lockage)	904	14.280	532	37.25
BWT (midpt to project)	373	36.450	1,394	38.24
BWT (Mobile Bay to project)	236	36.450	882	24.20

Emissions from transporting sediment would be offset somewhat by eliminating dredging for local borrow at the project site. Implementing sediment placement over stone shoreline protection would alleviate the quarrying and processing emissions.

Towboats consume diesel fuel, a non-renewable resource. As discussed previously transporting bulk materials by barge is more efficient than using other means of transportation (i.e. rail or truck). Using local materials minimizes fuel consumed for transportation, but consumes fuel by duplicate dredging. Energy is required to deliver materials that were prevented from natural deposition by manmade structures and alterations. The only mitigation for the transportation fuel consumption is to optimize transportation logistics. Planning and implementing a regular delivery system of sediment will facilitate cost reduction measures and ensure resource sharing of barge tow size is accomplished, minimizing fuel consumption. Once the land elevation is raised, river diversions are needed to nourish the new land areas and continue to offset the impacts of accelerated rise in sea level (Day et al. 2005).

5.17 Conclusions/Recommendations

Placing sediment into open water areas to create marsh is a tested and direct solution to land loss from subsidence or direct removal. Strategic placement of sediment could also reduce the potential for shoreline erosion by reducing the length of shoreline exposed, thus reducing fetch distances and minimizing the effects of wind/wave action. Projects typically dredge adjacent materials, however the effects of such borrow activities are unknown. Unfortunately, most of the materials dredged from the Mississippi River in coastal Louisiana are not currently used to rebuild the land. Working with the USACE on a regional basis to beneficially use all dredged materials should be implemented immediately. Cost sharing opportunities should make this economically viable source of sediment the first choice for marsh creation and barrier island restoration. Project and contract coordination issues could be overcome by establishing stockpile locations for the storage of dredged materials for later usage by CWPPRA projects. Even with 100% usage, the annual volume of dredged material from the New Orleans District is insufficient to address the annual land loss and maintain the status quo. Additional material may exist within the Mississippi River, but the quantities, quality, and locations are not precisely identified and some materials may be considered non-renewable. Regional sources of sediment are needed.

Upstream sediments from the Illinois Waterway and MKARNS; and sandy material stored in upland sites along the BWT are available. Sediments within the Mississippi River system would have been naturally transported by the river to coastal Louisiana if not for the series of levees and upstream reservoirs. The Illinois material would be suitable for marsh creation or nourishment. MKARNS sediment is larger than desired for barrier island restoration but would be appropriate as foundation support by lessening the initial water depth. BWT sands are very compatible in size for barrier island restoration. Taking advantage of the existing inland navigation system provides a means to transport sediment by barge for direct and strategic placement, creating upward growth and addressing land loss. A summary table of potential sources of sediment and sand is presented in Table 5.15.

Table 5.15 – Summary table of potential sources of sediment and sand.

Local Sources

Local Sources	Quantity of Material
Mississippi River maintenance	70 mcy per year[1]
Mississippi River deposits RM 20 to 35	6.15 to 20.5 mcy[2]
Proposed sediment trap above Head of Passes	9 mcy per year[1]

Imported Sources

Illinois Waterway – in storage	118 mcy[3]
Illinois Waterway maintenance	8.2 mcy per year[3]
Arkansas River Navigation System proposed deepening	11 mcy[4]
Arkansas River Navigation System – in storage	50.4 mcy[4]
Arkansas River Navigation System proposed maintenance	1.12 mcy per year[4]
BWT Waterway – in storage	30 mcy[5]
Notes: 1. USACE 2004 2. CPE 2004 3. Marlin 2005 4. USACE SWL 2005 5. Horn 2005	

Several sources of materials are available as shown in Table 5.15; however, the unit costs for importing sediment exceed those for recent CWPPRA projects that used local fill materials. The increased transportation costs for imported material can be offset by eliminating the need for:

- physical characterization of the fill material;
- geotechnical and geophysical investigations of local borrow sites;
- modeling studies to assess wave impacts; and,
- establishment of new upland storage locations and associated mitigation costs.

USACE has a Regional Sediment Management Program creating cost sharing opportunities. CWPPRA federal agencies should embrace a regional approach to beneficial use and seek additional partnerships that would further reduce the costs to import, making the material more competitive economically. Use of local materials may appear to be financially preferable in the short term, but simply dredging material and moving it around within the system from one location to another does not offer a sustainable solution to the ongoing loss in elevation coastwide. Local borrow sites are not monitored post construction to quantify the ecological and environmental impacts of their use. Without this data, CWPPRA federal agencies and the USACE will continue to focus on the least costly alternatives.

Costs are dependent upon transportation distances, but significant savings can be realized by seeking out partnership opportunities. Importation of sediments becomes more cost competitive compared to the price of local sources by taking advantage of cost sharing and optimizing logistical arrangements. A pure economic comparison does not incorporate the following environmental benefits:

- increasing land elevation in coastal Louisiana;
- avoiding habitat disruption of Louisiana coastal waterbottoms;
- eliminating placement of dredged materials on Oklahoma or Alabama terrestrial environments; or,
- restoring an ecosystem in Illinois.

Although some costs such as the real estate values for additional storage sites or mitigation costs can be captured, ecosystem preservation is difficult to quantify. Multiple ecosystems are restored by importing sediments instead of the current local inland usage philosophy of sacrificing one location for another. Similar in results to shoreline protection projects, borrowing and moving sediment around internally from within the coastal Louisiana system does not add elevation, increase the amount of sediments into this sediment starved environment, or sustainably address the overall land loss issue.

In addition to costing more, importing sediment consumes energy and produces emissions unlike the historical natural river transport and deposition mechanisms that originally built and sustained the land. However, it is a direct solution to address land loss in coastal Louisiana. Once the elevation is increased, river diversions would provide a sustainable and low energy mechanism for maintaining the marshes and offsetting ongoing subsidence and rising sea level.